VOLUME 57 [W. B. No. 992] NUMBER 8

OCT 21 1929

MONTHLY WEATHER REVIEW

AUGUST, 1929

CONTENTS

	Page
The floods of 1929 in the lower Mississippi Valley. Robin E. Spencer	317
Weather abnormalities in the United States (fourth note): Excessive rains and floods in southeastern Alabama. (6 figs.) A. J. Henry	319
Some characteristics of the rainy season at Tampa, Fla. (1 fig.) Walter J. Bennett	323
Change in the density of snow cover with melting. (2 figs.) George D. Clyde	326
The effect of rain on the snow cover. George D. Clyde	328
The frequency of tropical cyclones (West Indian hurricanes) that closely approach or enter continental United States. (2 figs.) A. J. Henry	328
The west coast atmospheric fault. (3 figs.) E. H. Bowie	332
The growth of the vessel weather service of the northeastern Pacific. W. J. Hussey	334
Meteorological needs of Class AIA airport. D. M. Little	336
What a tornado looks like. S. D. Flora	337
Pensacola waterspout of June 14, 1929. (3 figs.) P. G. Hale	338

	Page
NOTES, ABSTRACTS, AND REVIEWS:	
C. C. Simpson on the distribution of terrestrial radiation. H. H. K.	340
A study of ground water in the Pomperaug Basin, Conn., by Oscar Edward Meinzer and Norah Dowell Stearns. A. J. H.	341
W. Peppler on characteristic features of air current on coasts. *Transl. by W. W. R.*	343
Nile silt does not enrich the soil. A. J. H.	343
A rare day in August. A. J. H.	344
Meteorological summary for Chile, July, 1929. J. B. Navarrete. *Transl. by W. W. R.*	344
BIBLIOGRAPHY	344
SOLAR OBSERVATIONS	345
AEROLOGICAL OBSERVATIONS	347
WEATHER IN THE UNITED STATES	348
WEATHER ON THE ATLANTIC AND PACIFIC OCEANS	352
CLIMATOLOGICAL TABLES	356
CHARTS I-XV.	

UNITED STATES DEPARTMENT OF AGRICULTURE
WEATHER BUREAU
WASHINGTON, D. C.

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - - - - - For prices see page 4 of cover

CORRECTION

MONTHLY WEATHER REVIEW, December, 1928, Vol. 56:

Page 490, last paragraph, "rectilinear" should be "rectangular."

Page 494, first paragraph, the number "103" should be "97."

MONTHLY WEATHER REVIEW

Editor, ALFRED J. HENRY

VOL. 57, No. 8
W. B. No. 992

AUGUST, 1929

CLOSED OCTOBER 3, 1929
ISSUED NOVEMBER 5, 1929

THE FLOOD OF 1929 IN THE LOWER MISSISSIPPI VALLEY [1]

By R. E. SPENCER

[Weather Bureau, Washington, September, 1929]

Duration and crests.—In the three important particulars—height, duration, and resultant damage—the flood of 1929 in the lower Mississippi River ranks among the greatest Mississippi floods of record. A suggestion of its magnitude, both as to height and duration, may be gained from Table I below; as to damage, it compares closely with the flood of 1922 for the same reach of river, total losses in each case aggregating from $8,000,000 to $10,000,000.

Excepting only its great predecessor of 1927, the length of time the lower Mississippi remained above flood stage in 1929 is the greatest of any flood of record. It will be noted also (Table I) that the crests, by comparison with those of 1922 and 1927, were unusually late. Both this prolongation and lateness of crests are to be explained by the fact that the flood was not, strictly speaking, a single rise, but an upwardly progressive series of three, the first of which, combining at Cairo on March 20 from the upper Mississippi and Ohio Rivers, raised the lower river to flood stage, and the last and greatest of which, passing into the already full lower Mississippi from the Missouri, upper Mississippi, and Ohio Rivers about May 20—two months after flood stages in the lower river had been reached—brought the crests.

Table 2 below attempts to indicate the origin and progress of the three major lower Mississippi crests. (Their increments, discussed separately as Missouri, upper Mississippi, and Ohio River floods in the March, April, and May issues of this REVIEW, are not further considered here.)

[1] The section considered in this report is that from New Madrid, Mo., southward. Discussion of the floods in that portion of the Mississippi and its tributaries above New Madrid will be found in the issues of this REVIEW for March, April, and May of this year.

TABLE I.—*Crest stages and duration of lower Mississippi floods of 1922, 1927, and 1929*

[Flood stages in parentheses]

River and station	1922		1927		1929	
	Crest and date	Number of days above flood stage	Crest and date	Number of days above flood stage	Crest and date	Number of days above flood stage
Mississippi:						
St. Louis, Mo. (30)	34.0, Apr. 19	14	36.1, Apr. 26	32	34.6, Apr. 27–28	29
Cairo, Ill. (45)	53.6, Mar. 25 53.5, Apr. 25	53	52.8, Mar. 25 56.4, Apr. 20	88	52.7, May 19	80
New Madrid, Mo. (34)	41.6, Mar. 27 41.7, Apr. 26	55	40.4, Mar. 25 43.5, Apr. 21 [1]	108	41.3, May 19, 20, 23, 24.	93
Memphis, Tenn. (35)	42.6, Mar. 31 42.3, Apr. 29	56	41.4, Mar. 30 46.0, Apr. 23	107	41.7, May 26	80
Helena, Ark. (44)	52.3, Apr. 3 53.1, May 3	56	56.75, Apr. 26	111	52.6, May 28–30	90
Arkansas City, Ark. (48)	58.0, Apr. 22 57.7, May 3	59	60.4, Apr. 21 [1]	81	58.8, May 29–31	96
Greenville, Miss. (42)	52.1, Apr. 25 52.0, May 3	56	54.7, Apr. 21 [1]	60	53.2, May 29–June 2.	93
Vicksburg, Miss. (45)	55.0, Apr. 28 54.7, May 7	64	55.4, Apr. 22 [1] 58.7, May 4	106	55.2, June 6–7	101
Natchez, Miss. (46)	55.3, Apr. 26 [1] 52.8, May 9 [1]	65	55.3, Apr. 24 [1] 56.5, May 1 [1]	149	54.5, June 5–11	97
Baton Rouge, La. (35)	44.6, Apr. 27 [1] 45.7, May 16	72	47.8, May 15	153	43.5, June 10–13	97
Donaldsonville, La. (28)	35.8, Apr. 27 [1] 35.9, May 16	71	37.1, May 15	147	34.0, June 10	93
New Orleans, La. (17)	21.3, Apr. 25 [1]	63	21.0, Apr. 25 [1]	120	20.0, June 9	85
Atchafalaya:						
Simmesport, La. (41)	51.6, May 16	68	53.4, May 16		46.4, June 12–16	81
Melville, La. (37)	45.9, May 14	75	46.8, May 14	120	43.1, June 9–16	100

[1] Crevasse prevented further rise.

TABLE II.—*Crests, with dates, of rises directly contributory to major flood waves of lower Mississippi flood of 1929*

[Flood stages in parentheses]

Hermann, Mo. (Missouri) (21)	Grafton, Ill. (upper Mississippi) (18)	Cape Girardeau, Mo. (Mississippi) (30)	Paducah, Ky. (Ohio) (43)	New Madrid, Mo. (Mississippi) (34)	Memphis, Tenn. (Mississippi) (35)	Pine Bluff, Ark. (Arkansas) (25)	Arkansas City, Ark. (Mississippi) (48)	Vicksburg, Miss. (Mississippi) (45)	New Orleans, La. (Mississippi) (17)
20.2, Mar. 16	22.8, Mar. 20–21	34.1, Mar. 20	45.0, Mar. 14–15	41.0, Mar. 21	40.8, Mar. 24–25	22.2, Apr. 19	55.5, Apr. 17–19, 21–22.	52.7, Apr. 25–26, 29, 30.	18.6, May 2.
15.0, Mar. 30	22.9, Mar. 27	Steady rise from Mar. 26.	43.8, Apr. 3	40.6, Apr. 5–7	41.1, Apr. 11				
17.6, Apr. 5	22.8, Apr. 5–6								
19.8, Apr. 11	22.0, Apr. 12	34.9, Apr. 14	35.8, Apr. 17	41.3, May 19–20, 23, 24	41.7, May 26	27.6, May 20	58.8, May 29–31	55.2, June 6–7	20.0, June 9.
22.8, Apr. 26	26.2, Apr. 28	36.9, Apr. 29–30	Steady rise from Apr. 26.						
24.2, May 19	22.1, May 21	37.4, May 22	43.9, May 16						
24.8, June 8	16.6, June 5	33.0, June 10–11							

It is noteworthy of these major crests that while each one was made up of fairly considerable and almost simultaneous contributions from each of the great northern sources—the Missouri, the upper Mississippi, and the Ohio—yet these contributory rises could hardly of themselves all be considered very great floods (in fact, in the first two instances the Missouri did not attain flood stage at Hermann). This is interesting as a suggestion of what might result from a similar, and not impossible, combination of really great tributary floods. There have been examples enough in the past of the effect upon the lower Mississippi of one, or two, or three important but variously distributed increments, and the question has naturally often arisen as to the possible outcome of an ideal combination of maximum volumes from them all. This question is expertly considered in Frankenfield's discussion of maximum flood possibilities in the report on the Mississippi floods of 1927; it is answered in a very small way by the flood of 1929.

Crevasses.—In Supplement 29 of the MONTHLY WEATHER REVIEW, "The floods of 1927 in the Mississippi Basin," the following statement occurs: "During recent years the history of floods in the lower Mississippi Basin * * * is the history of loss and damage caused by the breaking of protection levees and the flow of water through the crevasses thus formed * * *. The public press stated that [in 1927] there were in all 226 crevasses, but it is thought that about three-fourths of these were of comparatively little consequence." In 1929 there was but 1 Mississippi crevasse below Cairo, against which, for the same reach of river, there were at least 5 having serious consequences in 1922, and at least 12 of corresponding importance in 1927.

The 1929 crevasses, of which the total for the entire lower Mississippi Basin is but four, are described by the officials in charge of the districts in which they occurred as follows: The order is by dates:

The first crevasse occurred on March 8, 1929. It was about 100 feet in length and was in the State line levee at Big Lake near Blytheville, Ark., drainage district No. 17. (Little River, Memphis district).

The second crevasse occurred on April 4 south of Henderson, La., in a levee built to confine the backwaters of the Atchafalaya Basin; and the failure was at the same point at which a similar break occurred last year. (Atchafalaya Basin, New Orleans district).

The third crevasse occurred in the Laconia Circle back levee on April 22, 1929. It was about 400 feet in length. (Mississippi River, Memphis district.)

The fourth crevasse occurred in the west bank of the floodway at a point about three-fourths mile south of the bridge over the floodway, on the Harrisburg-Marked Tree Road, west of Marked Tree, Ark., at about 2:30 a. m., May 26, and is reported to have been caused by an explosion of dynamite. It was about 240 feet in length. (St. Francis River, Memphis district.)

At first glance the crevasse and loss data of 1929 might seem rather emphatically to confirm the generalization quoted above as to the relation of these two features. Both reached maxima in one place—the Memphis district. The three worst of the four crevasses and nearly 75 per cent of the total reported losses occurred there. But examination of the tabulation of overflowed areas under the next section shows that the crevasses themselves contributed comparatively little to the total overflow—that far and away the greater part of it took place between the levees or was due (and particularly in the case of the St. Francis and the Yazoo Basins) to backwater.

It therefore appears that, in respect to the consequences of its crevasses, as well as in the smallness of their number, the flood of 1929 may fairly be considered exceptional. It is, at all events, an exception to the rule that the history of a great lower Mississippi flood is the history of damage due to broken levees; indeed, it stands as proof that even in spite of the great measure of protection the levees afford—and certainly their efficiency was abundantly demonstrated in this prolonged flood—disastrous overflows can still occur.

Overflow.—The extent of overflow—a reported total of 1,830,550 acres—was greatest in the Memphis district (which includes the reach of the Mississippi from below New Madrid to the mouth of the White River, and the St. Francis Basin in Arkansas), and in the Vicksburg district (which includes the Mississippi from the mouth of White River to Vicksburg, Miss., and the Yazoo Basin). Of the Memphis district the official in charge at that station reports as follows:

OVERFLOWED AREA IN THE MEMPHIS RIVER DISTRICT

In addition to an area of 676,830 acres along the Mississippi River and the lower portions of its tributaries in extreme western Tennessee, 45,900 acres of land were overflowed along the St. Francis River in the extreme eastern end of Craighead County, below Black Oak, Ark., and in the extreme eastern portion of Poinsett County and small area in the extreme northwestern portion of Crittenden County and the extreme northeastern portion of Cross County. In the St. Francis backwater area 215,820 acres were overflowed in the eastern portion of St. Francis County, east of Crowleys Ridge, a small portion of extreme southern Crittenden County, and an extensive area east of Crowleys Ridge in Lee and Phillips Counties. About 20,000 acres was overflowed outside the Mississippi River levee below Wabash, Ark., and 12,000 acres in Laconia Circle. The total acreage overflowed was as follows:

	Acres
From New Madrid, Mo., to the mouth of the White River along the Mississippi River between levees or between levees and hills	676,830
St. Francis Basin below Missouri-Arkansas line above Parkin, Ark	45,900
St. Francis backwater area south of Parkin, Ark	215,820
From Helena, Ark., to Laconia Circle outside levee	20,000
Laconia Circle	12,000
Total	970,550

In the overflowed area, land was under water from 12 weeks in the upper part of the district to 12½ weeks in the lower part, and the lowest land in the lower end was submerged for 15 weeks.

The depth of the water in the overflowed area averaged 5 feet in the upper end of the district, 7 to 8 feet in the middle portion, and 12 feet on the lowest land in the lower end. In the Laconia Circle it was 14 feet deep.

Considerable land near the river was damaged by seep water, owing to the great length of time the river was at a high stage.

The official in charge at Vicksburg, Miss., reports that in his district "more than 860,000 acres of land were overflowed in the lower Yazoo Basin from Mississippi backwater entering the basin through the mouth of the Yazoo River."

The overflow resulting from the Atchafalaya crevasse (No. 2 above) is reported by the official in charge of the New Orleans district as having covered a comparatively small area in St. Martin Parish.

Damage and the result of overflow.—Damage, the reported total of which was $9,979,601, was of course greatest where overflow was greatest—in the Memphis and Vicksburg districts. In the Memphis district the amount reported or conservatively estimated was $7,427,700, divided as follows:

Tangible property (buildings, factories, highways, bridges, etc.)	$743,200
Matured crops	82,000
Prospective crops (448,000 acres)	5,178,500
Livestock and other movable property	61,300
Suspension of business	930,700
Cost of moving people and property from flooded area	100,000
Cost of local assistance to refugees	157,000
Cost of protective measures to levees	75,000
Cost to railroads, etc., not included above	100,000

In addition, the losses to lumber interests (no estimate of which has been obtained) were undoubtedly great. It is reported that "one large company alone sustained a loss in production of several million feet, the mill having been closed down for more than 12 weeks."

The flood was the cause of four deaths in this district.

In all sections affected by overflow the delay to planting consequent upon the extreme lateness of the drainage of overflowed land was a very serious feature of the flood. This point is concisely covered in the Memphis station report: "In the upper part of this district it is stated that cotton will not mature if planted after June 1, and in the greater portion of the lower part it should be planted not later than June 10. As the land in the overflowed area was still submerged after these dates, it is reliably estimated that not more than one-half a crop can be raised this year—and not that much should there be an early frost."

In the Vicksburg district, as in the Memphis, the losses were in very large part to crops and prospective crops. The following is quoted from the report of the official in charge of the Vicksburg station:

> Of the 860,000 acres overflowed in the lower Yazoo Basin from Mississippi River backwater much formerly under cultivation has been abandoned as agricultural land on account of the relative frequency of flooded conditions thereon during recent years.
>
> Exact figures are not extant as to the acreage in the lower Yazoo Basin that would have been devoted to staple crops during 1929 had a flood not intervened; it is thought that 250,000 acres is a conservative estimate.
>
> Much of the land overflowed and intended for crops the present season has been planted subsequent to the subsidence of the water therefrom. The returns from these crops will depend upon the kind of weather following and the prices to be obtained. Compared with the price that might be obtained from crops originally intended to be planted on this land, a loss of about $10 an acre is probable, making a loss of $2,500,000 on the agricultural land overflowed.
>
> A tabulated loss was sustained by railroad companies in this district in protecting their property against flood damage, amounting to $51,901.26; intangible losses also occurred, difficult to enumerate, such as moving refugees, the abandonment of a branch line 45 miles in length from March 21 to July 15, and other losses due thereto.

There was also a considerable though undetermined loss in this district owing to the suspension of business activities.

The damage done in St. Martin Parish by the overflow from crevasse No. 2 (see above) was confined to the inconvenience and expense of moving several hundred families to safety and to an undetermined but probably not great loss owing to the delay in the use of the land for planting.

Savings by warnings.—In the Mississippi Valley, where the high standard of accuracy of flood warnings has long since established their dependability, and where predictions can be made so long in advance of impending conditions that their application reaches to some extent practically every activity in the valley, they have an importance which is, quite literally, immeasurable. As a flood year 1929 is no exception as an example of the widespread use of these warnings or of the difficulty of placing a value upon them. The Vicksburg district report states that "their value must have been considerable, but impossible of accurate tabulation"; and the official in charge of the Memphis station remarks as follows:

> The estimated money value of property saved by the flood warnings was $786,000. Of those reporting flood losses and savings resulting from the flood warnings, many stated that it was impossible to place a dollar valuation on the savings due to the warnings. That the amount given above is far below the actual savings is indicated by the following remarks by those reporting:
>
> "Impossible to estimate, but without such warnings loss of life and property would have been great."
>
> "There is hardly any way of estimating the worth of flood warnings. They are so necessary that we could not exist without them."
>
> The warnings were distributed by radio, telegraph, telephone, and mail, including distribution by the daily press, which gave much space to river news. Levee engineers and contractors, planters, lumber companies, and others in the threatened region called daily by long distance telephone for the forecasts and river stages. Many additional copies of the river bulletin were distributed by boats at way landings.

WEATHER ABNORMALTIES IN THE UNITED STATES

EXCESSIVE RAINS AND FLOODS IN SOUTHEAST ALABAMA

ALFRED J. HENRY

(FOURTH NOTE)

The most extraordinary floods in perhaps a century or more occurred in the streams of southeast Alabama, in March, 1929.

An account of these floods was given in this REVIEW for that month. In the haste necessary to the printing of that issue on schedule it was not possible to present a number of details that are essential to a proper understanding of the phenomenon.

Two river systems were involved—the Choctawhatchee and the Escambia. The most spectacular flood was that which submerged the town of Elba, at the junction of the Pea River and Whitewater Creek. The Pea River, a stream probably unknown outside the limits of the State is the main tributary of the Choctawhatchee. The width of Pea River at low water is 150 feet; at bankful stage 225 feet. The Pea River north of Elba where it unites with Whitewater Creek is about 100 feet wide at low water; Whitewater Creek drains a larger area north of Elba than does the Pea River.

The drainage of southeast Alabama is wholly to the Gulf of Mexico through a number of streams, naming them in order from east to west, the Chattahoochee, although it carries a relatively small amount of Alabama drainage would come first, then follows the Choctawhatchee and its main tributary the Pea. Next in order and importance is the Escambia with its chief tributary, the Conecuh entirely within Alabama. All of these streams originate in the Coastal Plain of Alabama which gradually slopes from about 600 feet in the north to Gulf level.

A map, Figure 1, shows the streams-above mentioned and the location of rainfall stations in the several basins. The 100 and 500 foot contour lines are given. The latter barely touches the headwaters of the Pea, about 125 miles from the Gulf of Mexico. The slope is therefore one quarter of a foot per mile.

The rains which led up to the floods began on February 27, continued on the 28th, and then ceased until March 4–5, when a second period of heavy rains set in. Beginning on the 12th a third and the most intense of the four periods began. The rains of this period culminated on the 15th as may be seen from the tabulation below. While torrential downpours occurred in southern Alabama the rainfall of the entire State was the most extraordi-

nary in the last 50-odd years, if not in a century. The *average* of the northern part of the State as deduced from the records of 25 stations was 12.02 inches; for the southern half with 47 stations it was 17.12 inches, and for the State as a whole with its 52,000 square miles of area, the *average* was 15.35 inches or 9.60 inches greater than normal.

We are more particularly interested, however, in the daily amounts at stations in and near the basins of the two river systems involved. I therefore show in the table next following the 24-hour rainfall at those stations and from the data of that table an isohyetal chart giving the total rainfall in the two basins for March 12–16 as show in in Table 2 is superposed on Figure 1.

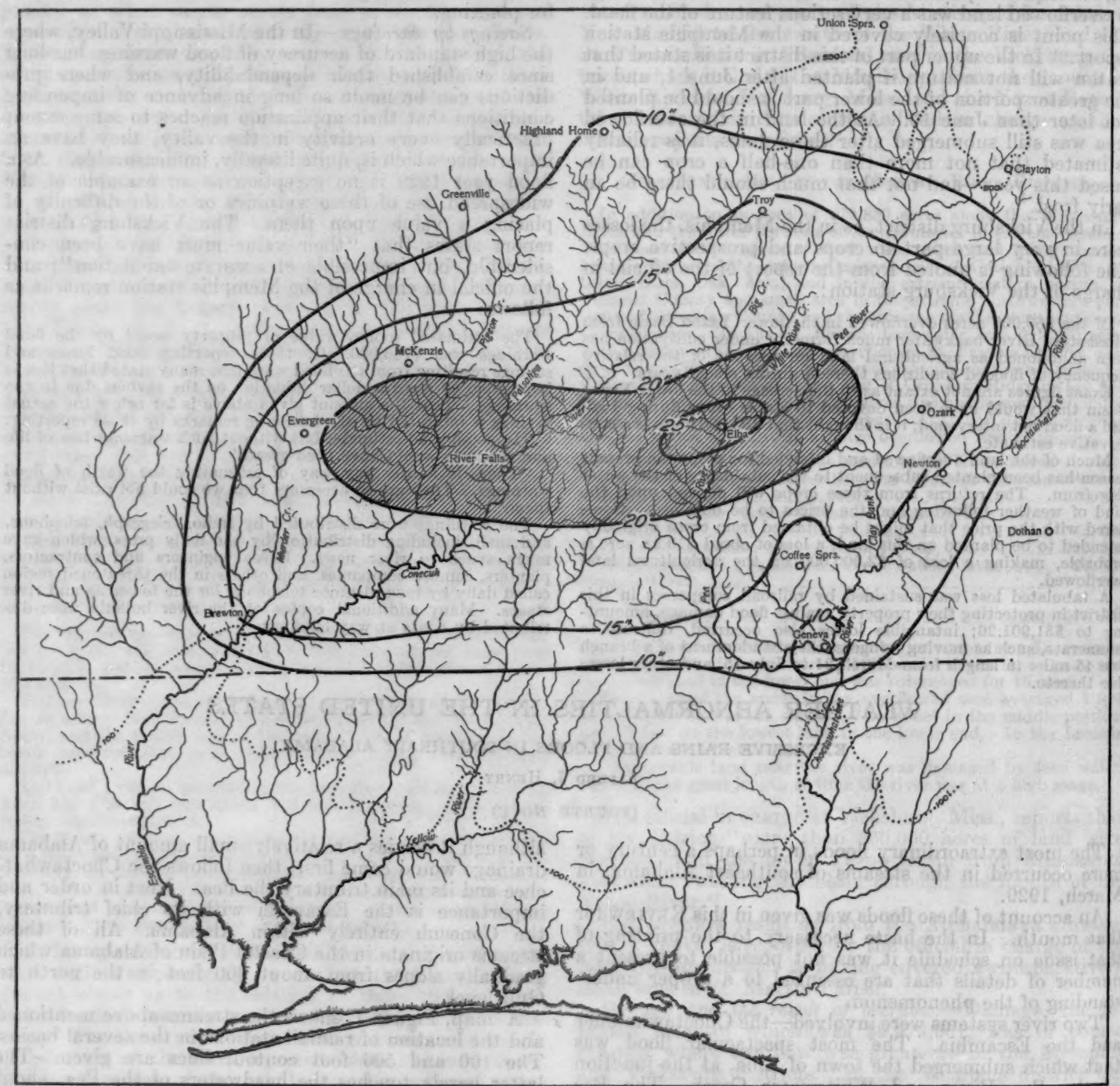


FIGURE 1.—Map of Choctawhatchie and Conecuh River basins with contour lines and total rainfall March 12-16 superposed

TABLE 1.—*Average rainfall in Alabama on the dates named (inches and hundredths).*

Dates	Amounts	Dates	Amounts	Dates	Amounts
Feb. 26	1.97	Mar. 5	1.40	Mar. 15	4.89
Feb. 27	2.43	Mar. 12	.81	Mar. 22	.76
Feb. 28	1.10	Mar. 13	1.93	Mar. 23	.77
Mar. 4	2.28	Mar. 14	4.70		

The rainfall map when considered in connection with the fact that the ground was saturated with water from the rains immediately preceding those shown on the charts make it clear why so great a quantity of water descended on the towns of Elba and Brewton, for example. The position of Elba at the junction of Whitewater and Big Creeks with the Pea River must have been a large factor in the water concentration. In the case

(To face p. 320)

FIGURE 2.—Airplane view of the flooded town of Elba, Ala., March 15, 1929. (Photo by Fourth Photographic Section, Air Corps, Maxwell Field, Montgomery, Ala.)

UNIV. OF MICH.

(To face p. 321)

FIGURE 3.—Airplane view of the flooded town of Brewton, Ala., March 15, 1929. (Photo by Fourth Photographic Section, Air Corps, Maxwell Field, Montgomery, Ala.)

of Brewton on the lower Conecuh River, the local drainage at that place also conspired with the heavy rains to send a flood of water into the streams that converge a short distance below the town. Airplane views show the flood situation at both these places (figs. 2 and 3).

TABLE NO. 2.—*Daily precipitation in the basins of the Choctawhatchee and Conecuh River systems for the dates given* [1]

Stations	Altitude, feet	Mar. 12	Mar. 13	Mar. 14	Mar. 15	Mar. 16	Total
Choctawhatchee:							
Elba	2.04	.....	2.20	7.40	20.00	.....	29.60
Clayton	5.89	0.12	1.02	2.07	5.61	0.09	8.91
Dothan	.....	1.11	.66	9.00	2.68	.....	13.45
Ozark	4.00	.10	1.02	3.00	13.40	.05	17.57
Newton	2.16	.30	.67	1.71	11.80	.....	14.48
Union Springs	4.85	.05	2.30	2.65	3.04	.....	8.04
Conecuh:							
Highland Home	(?)	1.32	2.00	5.75	3.10	.....	12.17
McKenzie	4.51	.20	3.30	8.00	8.25	.....	19.75
Troy No. 1	5.81	1.40	2.35	8.00	4.00	.....	15.75
Greenville	4.44	.32	2.64	2.40	3.10	.....	8.46
Brewton No. 2	.85	.....	2.43	.83	13.00	.....	16.26
Evergreen	2.85	.15	2.85	8.70	7.76	.....	19.46
Geneva	1.07	T.	1.30	1.90	11.00	1.00	14.20
River Falls	1.59	T.	3.00	6.03	11.20	.....	20.23

[1] Precipitation at the above stations is measured in the morning except at Troy No. 1 and Highland Home, where it is measured late in the afternoon.

Practically all of southeastern Alabama and the contiguous part of Florida is low country, a coastal strip in Florida that ranges in width from 20 to 60 miles is less than 100 feet above mean Gulf level (see the contour lines in fig. 1). The 500-foot contour barely reaches the headwaters of the Pea River and we are probably justified in saying that the orographic features of southern Alabama are without pronounced influence upon the rainfall of that section.

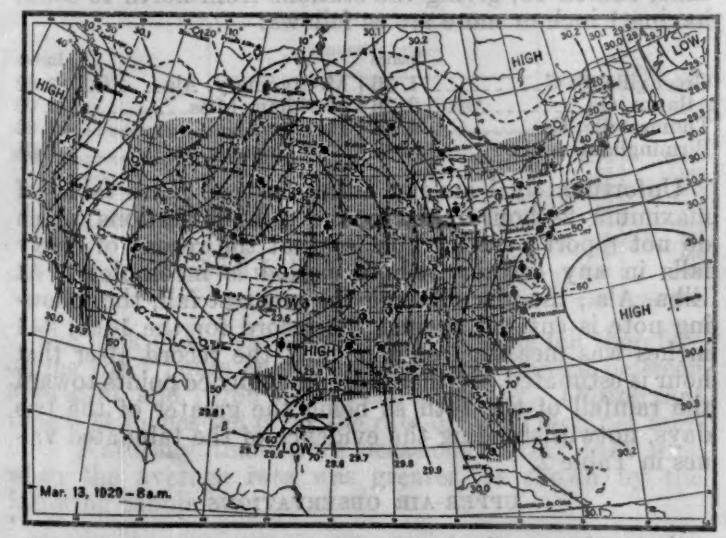


FIGURE 4.—Weather Map, March 13, 1929—Isobars in full, isotherms in dashed lines; precipitation in last 24-hours shown by vertical shading. The state of the weather at time of observation is shown by the shading of the small circles; no shading indicates clear skies and complete shading cloudy sky; the letter R when combined with the wind-direction arrows indicates that rain is falling at time of observation

Certain limited areas, however, received much greater amounts than others closely surrounding, thus Dothan in Houston County, recorded a rainfall of 9 inches on the 14th when Newton, about 14 miles, to the northwest received but 1.71 inches. Mobile at the head of the bay of the same name measured a 24-hour rainfall of 10.71 inches on the 14th whereas the fall at Pensacola, about 60 miles to the southeast, registered but 0.09 inch and the total for the month of March was but 6.42 inches.

The area of heavy rains is elliptical in shape, with a maximum length of about 100 miles and a width at the widest point of about 20 miles.

As to the cause of the heavy rains on the 14th and 15th of March, the best that can be said is that they were not due to surface relief, neither is the assumption of a convergence of air streams tenable; thus we are left with the distribution of temperature in the vertical as the only reasonable alternative. Nothing is known of the vertical temperature gradient, although a kite flight on the 14th made at Due West, S. C., distant several hundred miles from the area of heavy rain, showed an inversion of temperature throughout the first 500 meters, practically an adiabatic lapse rate (0.91° C.) for the next 800 meters and 0.84° C. throughout the remaining 1,000 meters. Whatever the explanation, the facts are that heavy local

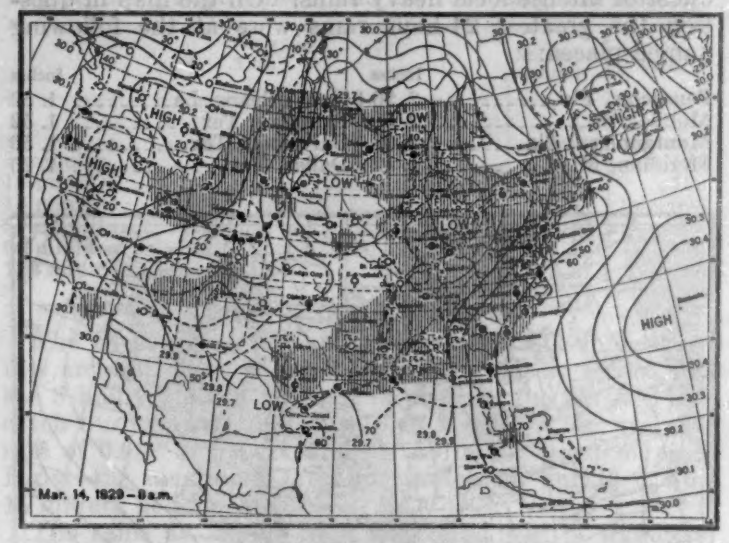


FIGURE 5.—Weather Map, March 14, 1929

downpours occur with sufficient frequency to be taken into account in planning flood protection measures and finally in planning or selecting sites for settlement along any stream, a site at which a great volume of discharge will converge should either be avoided entirely or properly safeguarded.

THE WEATHER MAPS

The weather maps prior to and during the days with heavy rain have been examined with the following results. The maps for the four groups of days with heavy rains show considerable similarity there being in each case a strong oceanic anticyclone centered over the western part of the North Atlantic in the vicinity of the Bermudas and concurrently therewith on two out of four of the groups there was a great shallow barometric depression or a trough of low pressure over the continent immediately to the westward of the oceanic anticyclone. This pressure distribution is favorable to rain in the Gulf States whenever a cyclonic system approaches from the west of the continent. Without further dwelling on this feature I call attention to the three weather maps reproduced as Figures 4, 5, and 6. The first of these shows a pronounced oceanic anticyclone with central pressure of 30.48 inches at Hamilton, Bermuda. This anticyclone controls the winds of eastern United States, one might say regardless of the pressure distribution over the continent, which in this case joins with the oceanic anticyclone in causing a broad sheet or mass of oceanic air to flow from southeast to northwest over a very large area as may be seen from the map. It is further emphasized that the cyclonic system over Nebraska has made a sharp turn towards the northeast in the 24 hours immediately preceding the morning of the 13th. As a result, for rea-

sons which need not be entered into, two secondary cyclonic systems or preferably, we may call them, barometric depressions are in course of development, one over Oklahoma, the other over the mouth of the Rio Grande.

In the great stream of air moving from southeast to northwest as shown on the map for the 13th there will be places where the rainfall will be greater than at others. The reasons why this is so are not always or indeed often apparent; it may be said in passing that features of surface relief tend to produce heavy rainfall, or regions over which air streams converge will also receive heavy rains, but by far and large vertical convection is the great producer of intense local heavy rains. On the map in question the greatest 24-hour rains were at the following named places:

	Inches		Inches
Pensacola, Fla	2. 90	New Orleans, La	1. 32
Mobile, Ala	2. 58	Palestine, Tex	1. 52
Montgomery, Ala	2. 08	Galveston, Tex	1. 56
Meridian, Miss	1. 42	Dallas, Tex	1. 26

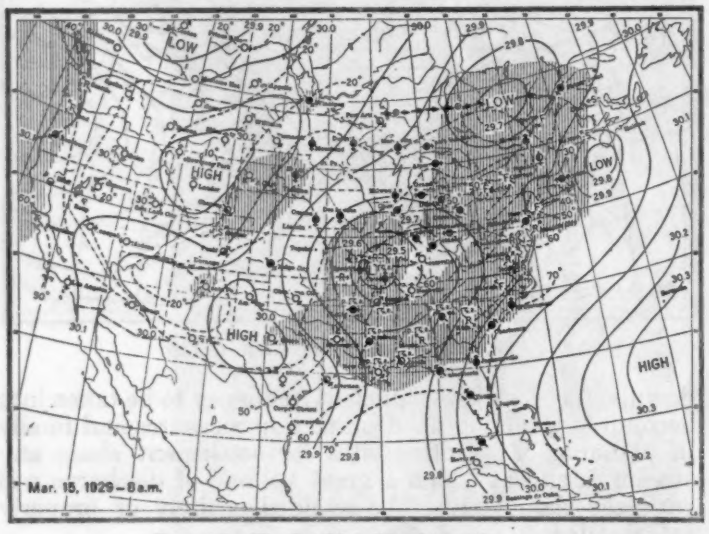


FIGURE 6.—Weather Map, March 15, 1929

On the ground that the atmosphere above stations situated on the coast should contain a greater quantity of moisture than the air far from the coast and therefore the rainfall at coastal stations should be greater than inland ones, we should expect the greater rains to be at coastal stations. This expectation is only partly justified. It can be shown that points in the middle of the continent of North America may and do have as great short period rains as points immediately on the coast.

While the rainfall of the 13th is not in itself noteworthy the weather map has been reproduced to show the change in surface pressure that took place in the succeeding 24 hours.

From Figure 5, weather map of March 14, it is seen that the oceanic anticyclone is still the dominating element in pressure distribution and that by reason of its static qualities pressure to the westward over the continent is apparently greatly disorganized.

There is a great shallow depression covering the Lake region and the Northwest with three centers of low pressure. The isobar of 29.8 inches makes a bend northward from the Gulf of Mexico into Alabama and this loop may be an indication of the northeastward spread of the secondary that on the 13th was centered over the mouth of the Rio Grande.

The rainfall for the 24 hours ending with 8 a. m. seventy-fifth meridian time on March 14, when the map was issued, is available only for the stations of the bureau that telegraph their observations to a central point. Following are the largest amounts on that date:

	Inches		Inches
Asheville, N. C	1. 62	Vicksburg, Miss	2. 68
Atlanta, Ga	2. 12	New Orleans, La	1. 22
Mobile, Ala	3. 98	Knoxville, Tenn	1. 24
Montgomery, Ala	3. 16	Chattanooga, Tenn	3. 66
Birmingham, Ala	4. 12		

At two stations in the general rain area—Augusta, Ga., and Columbia, S. C.—no rain fell and the rain at surrounding stations in that region was very light.

Out of the apparently chaotic pressure distribution of the 14th there arose, as may be seen from the weather map for the 15th, Figure 6, a perfectly organized cyclonic system with central pressure of 29.38 inches at St. Louis, Mo., a fall of 0.36 inch in 24 hours and also a further development of cyclonic activity over Canada southeast of Hudson Bay. These developments are particularly interesting from the dynamical viewpoint but in the absence of definite information as to the method of origin the matter is passed over without further comment. The result of the development, however, was the termination of the rainy period in the Gulf States; these rains did not cease before vast quantities of water were precipitated over Alabama and contiguous States. The greatest falls for the 24 hours ending at 8 a. m., seventy-fifth meridian time, March 15, giving the stations from north to south having 1 inch or more are as follows:

	Inches		Inches
Greenville, S. C	1. 36	Montgomery, Ala	2. 82
Atlanta, Ga	2. 26	Meridian, Miss	2. 00
Thomasville, Ga	4. 64	Mobile, Ala	8. 92
Birmingham, Ala	1. 40	New Orleans, La	1. 08

Unfortunately I am not able to extend these tables of maximum 24-hour rains to the rainfall stations which do not report by telegraph, so that the record of heavy falls in any certain 24-hour period is incomplete. At Elba, Ala., the place having the greatest fall, the following note is entered against the record for the 14th: "14 inches was measured at 4 p. m.," the record after that hour is estimated. Other indirect evidence points toward the rainfall of the 14th as being the greater of the two days, notwithstanding the evidence of the tabulated values in Table 2.

UPPER-AIR OBSERVATIONS

As so frequently happens by reason of cloudy skies and rain, upper air observations are not forthcoming when most needed. I gather from the free air observations prior to the rains of March 12–15 that there may have been in the beginning something like a mass movement of the air over the east Gulf States from the west or southwest. In the absence of definite information with respect to the upper air, let us turn our attention to the surface winds and such inferences as may be drawn from them as to the direction of the upper winds.

As early as the 10th of March surface winds over Alabama were uniformly from the northeast and of continental origin. On the 11th they had become easterly, and on the 12th, when general rains began, they had shifted to southeast and were of oceanic origin. On this date the barometric gradient due to the oceanic anticyclone acting jointly with the gradient due to a cyclone centered over eastern Colorado doubtless caused an acceleration of the southeast winds and they continued throughout that and the following day.

The upper winds on the 13th, 14th, and possibly for a part of the 15th must have been from a westerly quarter, basing this statement on the well-known turning of the surface winds with altitude.

As previously stated, the development and movement of the middle Mississippi Valley cyclone of the 15th must have resulted in a more northerly component being injected into the upper winds over east Gulf States on that date.

The longer axis of the area of heavy rains on the 14th was in a n./s. direction, and on the 15th it was ne./sw. when the areas contiguous to Alabama are considered. The isohyetal chart (fig. 1), however, gives the impression that the heavy rains were local to the watersheds under discussion.

It may be asked, how was the excessive rain distributed throughout the 24 hours? The answer for a single station having an automatic register is found for Mobile, Ala. Excessive rains occurred at that station on March 12, 13, and 14. The maximum amount for any 24 hours was 11.59 inches on the 14th and 15th. The excessive rate began at 3:46 a. m. and ended temporarily at 4:13 a. m. The rate continued as shown in the exhibit below:

Mobile, Ala.

Date	Excessive rate—		Amount	Rate per minute
	Began	Ended		
Mar. 14	3:46 a	4:13 a	0.76	0.028
Do	5:08 a	5:58 a	.95	.019
Do	5:58 a	6:48 a	.66	.013
Do	6:48 a	7:38 a	.82	.016
Do	7:38 a	8:28 a	.85	.016
Do	8:28 a	9:18 a	1.03	.021
Do	9:18 a	10:08 a	.68	.014
Do	9:54 p	10:56 p	1.48	.024

The bulk of the excessive rain at Mobile fell therefore during the 7 hours and 11 minutes that elapsed between 3:46 a. m. and 10:56 a. m. of the same day. During that time 6.71 inches fell or at the rate of 0.016 inch per minute. Naturally there were occasions during that time when the average rate was greater, as shown by the following tabulation:

Time	Maximum amount	Rate
	Inch	*Inch per minute*
5 minutes	0.40	0.08
10 minutes	.71	.07
15 minutes	.97	.06
30 minutes	1.67	.06
60 minutes	2.32	.04
120 minutes	2.66	.02

For comparative purposes the record of the greatest 24-hour rainfall in the United States which occurred at Taylor, Tex., September 9 and 10, 1921, is given below: [1]

Time	Maximum amount	Rate
	Inch	*Inch per minute*
5 minutes	0.72	0.144
10 minutes	1.12	.112
15 minutes	1.47	.098
30 minutes	2.56	.085
60 minutes	4.25	.071
120 minutes	7.51	.063

The 24-hour rainfall at Taylor was 23.11 inches; of this amount there is a continuous automatic record for the 3 hours 6:42 p. m. to 9:42 p. m. of the 9th and the catch during that time was 10.44 inches, or an average rate of 0.058 inch per minute. As in the previous case I give the maximum rates for the storm during 5, 10, 15 minute periods, etc.

The rains at Taylor were associated with a thunderstorm and this was also the case at Mobile; we are therefore able to conclude that the exceptionally heavy rains in both cases were the result of violent convective action.

RECAPITULATION

The immediate and direct cause of the overflow was the heavy downpours of rain on March 14 and 15 in the basins of the Choctawhatchie and Conecuh Rivers at a time when due to previous rains the soil was saturated with water and the streams were at bankful stages. Other contributing causes were the slight slope of the rivers in that part of Alabama and consequently the very slow disposal of the water by the trunk streams. The fact that the local drainage at Elba and Brewton permitted a large volume of water to be passed into the trunk stream at those points undoubtedly was a very considerable factor in the flooding that took place.

[1] cf. McAuliffe J. P., Excessive rainfall and floods at Taylor, Tex., Mo. Wea. Rev. 49: 496-97.

SOME CHARACTERISTICS OF THE RAINY SEASON AT TAMPA, FLA.

By WALTER J. BENNETT, Meteorologist

The conventional and convenient division of the year into four seasons of three months each is not entirely satisfactory for central Florida. Considering temperature, we have winter, including December, January, and February; spring, March, April, and May; but when we come to summer we must take in four months, June, July, August, and September, for September averages only 1.4° cooler than August. This leaves us only two months, October and November, for the autumn.

Considering precipitation, the four summer months stand together because of abundant rainfall. Almost two-thirds (61 per cent) of the average annual rainfall occurs in these four months—that is, in one-third of the year. September, the driest of the four, has more than twice as much rain as May or October. During this season the probability of a measurable amount of rain on any day is 52 per cent, or a little better than one day out of every two; and the probability of a trace or more of rain is 64 per cent, or not quite two days out of every three. During the other eight months the probability of 0.01 inch of rain any day is 21 per cent, or only one day out of five; and of trace or more of rain 29 per cent,

or less than one day out of three. The average daily rainfall for the rainy season is 0.23, for the other eight months only 0.08.

The actual rainy season for any particular year, of course, does not coincide exactly with the calendar months. It is sometimes difficult to say just when it does begin or end, but we consider it as beginning when rains occur with fair regularity one day out of two and as ending when rains become less frequent.

Table 1 gives the dates of beginnings and endings for each year since 1890, the total duration of the rainy season in days, the total precipitation for those days, and the percentage of the total annual rainfall.

TABLE I.—*Dates of beginnings and endings of rainy season; total duration in days; total rainfall and percentage of total annua rainfall*

Year	Beginning—	Ending—	Duration	Total rainfall	Per cent of annual
1890	May 24	Oct. 2	132	46.20	
1891	June 8	Oct. 15	130	31.57	71
1892	June 2	Oct. 1	122	31.99	69
1893	May 30	Oct. 3	127	28.69	59
1894	May 26	Oct. 9	136	52.55	79
1895	May 30	Sept. 15	109	28.77	57
1896	May 20	Sept. 21	125	41.10	69
1897	June 3	Sept. 30	120	33.26	61
1898	June 1	Sept. 27	119	38.65	76
1899	...do...	Sept. 21	113	40.99	64
1900	June 6	Sept. 16	103	23.26	42
1901	June 2	Oct. 3	124	27.76	66
1902	May 29	Sept. 23	118	35.18	70
1903	June 6	Sept. 18	105	31.24	55
1904	...do...	Sept. 20	107	22.54	50
1905	June 9	Sept. 30	114	37.20	73
1906	May 14	Oct. 2	142	40.96	79
1907	June 20	Sept. 29	102	27.11	60
1908	June 11	Sept. 30	112	21.40	66
1909	May 29	Sept. 21	116	37.19	79
1910	June 8	Oct. 18	133	30.77	74
1911	June 3	Sept. 27	117	24.77	56
1912	May 29	Oct. 4	129	44.70	67
1913	June 21	Sept. 21	93	26.35	59
1914	May 31	Oct. 5	128	23.94	51
1915	May 29	Oct. 8	133	23.81	52
1916	June 8	Sept. 18	103	26.52	66
1917	June 10	Sept. 30	113	27.33	73
1918	June 9	Oct. 5	119	21.38	59
1919	May 20	Sept. 20	124	32.35	60
1920	June 2	Sept. 30	121	28.84	58
1921	June 21	Sept. 10	82	17.19	35
1922	...do...	Oct. 3	105	27.85	58
1923	May 14	Sept. 27	137	25.31	68
1924	June 2	Oct. 11	132	33.67	61
1925	May 16	Sept. 19	127	41.52	68
1926	May 25	Oct. 5	134	26.55	59
1927	June 7	Sept. 21	107	21.65	62
1928	June 10	Sept. 30	113	33.30	69

The rainy season may begin as early as the middle of May (May 14, 1906 and 1923), or may be delayed as late as the middle of June (June 21, 1913, 1921, and 1922). The ending may be before the middle of September (September 10, 1921), or run past the middle of October (October 18, 1910). The average beginning is about June 2, and the average ending about September 28, making an average duration of 119 days. The shortest on record was only 82 days (1921), and the longest 142 days (1906). The wettest rainy season was from May 26 to October 9, 1894, during which time 52.55 inches of rain fell; and the driest rainy season was in 1921, when only 18.67 inches fell from June 21 to September 10.

Sometimes there will be a shower every day for a week or longer. The longest period with rain every day (trace or more) was 26 days, July 28 to August 22, 1905. During this period 14.65 inches of rain fell. The greatest rainfall on record in 24 consecutive hours was 6.56, September 20–21, 1897. The greatest 2-day rainfall was 8.65, and the greatest 3-day rainfall 13.19, both in September, 1912. Very heavy rain may fall in a very short time. The records for 5, 10, and 15 minutes are held by September 26, 1924, when 1.05 fell in 5 minutes, 1.66 in 10 minutes, and 2.03 in 15 minutes. The records for half-hour, hour, and 2-hour periods are held by August 28, 1925, when 2.72 fell in half an hour, 4.01 in one hour, and 4.59 in two hours. Excessive precipitation as heavy as an inch or more an hour occurs between three and four times per season, and a rainfall of an inch in 24 hours, about nine times per season.

Often there is a break during the rainy season of a week or more. The longest period without rain during this season was 11 days in June, but periods of 9 days without rain have occurred in July, August, and September. Showers are most common in the afternoon, and an all-day rain is practically unknown.

The average daily duration of rainfall, *including* traces has been calculated for a period of 24 years, 1905 to 1928, and it has been found that June has an average of 1 hour 23 minutes per day; July, 1 hour 32 minutes; August, 1 hour 36 minutes; and September, 1 hour 23 minutes. For the whole season the average is 1 hour 29 minutes, practically 1½ hours per day, or about 6 per cent of the time. Thus it happens that the average daily duration of rainfall for the rainy season at Tampa, is exactly the same as the average daily duration for the whole year at Baltimore, the Baltimore record *excluding* traces. (Mo. Wea. Rev., Feb., 1929, pp. 50–52.) The month with the least duration was September, 1910, with an average of 15 minutes per day, and the month with the greatest duration was June, 1912, with an average of 4 hours 48 minutes per day.

Table 2 gives the average duration per day of rainfall, including traces, for the months of June, July, August, and September and for the season, each year from 1905 to 1928, in hours and minutes.

TABLE 2.—*Average daily duration of rain (including traces) in hours and minutes*

Year	June	July	August	September	Season
1905	1:05	1:37	3:17	2:16	2:04
1906	1:29	2:07	2:04	1:03	1:41
1907	1:23	1:12	1:21	1:23	1:19
1908	1:52	1:04	2:06	2:16	1:49
1909	2:07	2:28	2:37	0:40	1:58
1910	1:42	2:02	1:34	0:15	1:24
1911	1:07	1:44	2:06	1:10	1:32
1912	4:48	1:15	1:04	3:03	2:31
1913	0:47	1:16	2:02	0:59	1:16
1914	1:09	1:01	0:49	1:31	1:00
1915	0:42	1:06	1:13	0:45	0:57
1916	1:06	1:07	1:33	1:40	1:22
1917	0:56	1:16	2:20	1:26	1:30
1918	0:35	0:48	1:29	0:57	0:57
1919	1:02	2:31	0:46	0:50	1:18
1920	1:07	1:36	1:19	1:48	1:27
1921	0:40	2:20	0:38	0:30	1:02
1922	1:14	1:36	1:58	2:22	1:48
1923	1:28	1:14	1:16	1:06	1:15
1924	1:03	1:50	0:53	1:19	1:16
1925	1:09	1:47	1:12	0:30	1:10
1926	2:03	1:17	1:24	1:37	1:35
1927	1:03	1:31	0:51	0:44	1:02
1928	1:34	1:16	2:25	3:48	2:15
Means 1905 to 1928	1:23	1:32	1:36	1:23	1:29

In spite of the heavy rains, there is usually an abundance of sunshine. Up to noon the sunshine runs 74 per cent of the total possible. The records for the past 32 years show that there are only two or three days per summer with no sunshine at all. The average per cent of possible sunshine is 67 for June, 62 for July, 65 for August, and 66 for September. The average daily duration of sunshine is June, 9 hours 16 minutes, or

9.3 hours; July, 8 hours 35 minutes, or 8.6 hours; August, 8 hours 29 minutes, or 8.5 hours; and September, 8 hours 12 minutes, or 8.2 hours.

During the eight months, October to May, the rainfall is to a large extent due to areas of low pressure crossing the country, and is therefore usually associated with barometer readings below normal. Occurrence is almost as frequent at night as during the day. The rainfall of the rainy season, however, is mostly due to local thundershowers, which are more probable in the afternoon than in any other portion of the day. They occur nearly as often with high barometer as with low. From a 5-year computation, 1924 to 1928, the probability of rain for June, July, August, and September during a day following an 8 a. m. barometer reading of 30.00 or above is 60 per cent; while the probability of rain with the barometer below 30.00 is 69 per cent.

Thunderstorms.—The thunderstorm is an important element in the climatology of Tampa, and of particular importance during the rainy season. A thunderstorm is recorded whenever thunder is distinctly heard at the station, even though neither lightning nor rain is observed. This is in accordance with instructions, practically unchanged since 1890. (Mo. Wea. Rev., July, 1915, p. 323.) During the early years, up to and including 1903, thunderstorms apparently were not so carefully recorded. The average number of thunderstorms, 1890 to 1928, is 81 per year, of which 61, or 75 per cent, were during the rainy season. The average number, 1904 to 1928, is 94 per year, of which 73, or 78 per cent, were during the rainy season. There is a wide variation in the number of thunderstorms from year to year. Nineteen hundred and four had 123, and August of that year had a thunderstorm every day. The year 1908 had only 73 thunderstorm days. Comparison with the records of other cities show that Tampa has more days with thunderstorms than any other regular Weather Bureau station in the United States.

The causes of this frequency are not hard to find. Insolation is intense from a sun that nearly reaches the zenith at meridian height, while the warm waters of the adjacent Gulf of Mexico furnish an ample supply of moisture. Conditions thus favor the formation of local or heat thunderstorms. Also, wind directions are favorable. The prevailing wind direction at Tampa is northeast, for the city is within the trade-wind belt for a large part of the year. But because of the unequal heating of the land surface of the peninsula and the water surface of the Gulf, we have a sea breeze, or prevailing winds from the southwest and west in the afternoons during summer. Often, however, while the winds are from the southwest, clouds can be observed moving from the northeast, showing that the sea breeze does not extend very high. I shall not attempt to explain the exact mechanism of the thunderstorm, but while they are of local or heat origin primarily, their formation is apparently helped by a rolling up of the vapor-laden air from the Gulf, as it meets the prevailing northeast winds.

The average amount of cloudiness for the rainy season at 8 a. m. (39 years) is 4.0 tenths; the average for 12:30 p. m. for the past 11 years is 6.5 tenths, showing how cloudiness increases up to noon. In the afternoon the increase is more marked up to 5 p. m., although no observations are available for averaging at that hour. There is probability of thundershowers somewhere in central Florida any day during the months of June, July, August, and September, although often they are widely scattered and cover only a small total area. A marked low-pressure area replacing the normal high over Bermuda and the South Atlantic coast usually causes a cessation of thundershowers in the Florida Peninsula, but the occurrence during the rainy season is quite rare.

Thunderstorms occur mostly in the late afternoon, but they may occur at any hour, and one day may have several distinct storms, as many as four in one day having been recorded. Showers that resemble thundershowers, even to making a record of a pronounced thunderstorm "nose" on the barograph trace, are sometimes noted when no thunder is heard. According to existing instructions these are not classified as thunderstorms.

As to damage by lightning, there seems to be no more in Florida than in some of the northern States where thunderstorms are less frequent. In tropical and subtropical countries lightning seems to pass more frequently from cloud to cloud and less frequently from cloud to earth. (Ward's Climate, p. 87; Humphrey's Physics of the Air, W. B. Edition, 1920, pp. 320, 354, 355.)

Hail has been recorded in the vicinity of Tampa only thirteen times in the past 39 years, and only four times during the rainy season. Apparently temperatures in the thunderheads rarely reach as low as the freezing point.

During the summer season we have a thunderstorm about one day out of every two, and one is particularly likely to form whenever the temperature threatens to go too high for comfort, and when the humidity seems oppressive. Coming in the afternoon, just before the time we might expect the maximum temperature, such a storm cuts off the peak of the temperature curve and causes a sharp drop, a fall of 15° in half an hour being quite frequent. Although the temperature may rise again after the storm is over, it never goes as high as it was before. This is one of the reasons why Tampa can say that the official thermometer has never gone above 97½°, and that a temperature of 95° or above occurs only once in a summer on the average.

Hourly distribution of rain and thunderstorm.—During the eight months, October to May, rain is almost as likely one hour as another. But during the summer season the probability of rain is very much greater during the afternoon hours, amounting to 21 per cent for the hour ending 5 p. m., while for the hour ending 4 a. m. the probability is only 3 per cent. The thunderstorm curve shows a still greater range, the probability for the hour ending 5 p. m. being nearly 22 per cent, and for the hour ending 5 a. m. only 1 per cent. The percentages of probability for the different hours are shown by Table 3 and also on the accompanying figure. We can not add these percentages together, however, to get the probability of rain in two or more hours, for the same shower or thunderstorm may extend through two or more hours and so be counted more than once. These percentages of probability of rain were obtained by counting the total number of individual hours in the past 24 years in which rain (trace or more) was recorded, and then dividing the sum by the total number of days, 24 × 122 or 2,928. The thunderstorm figures were obtained in a similar manner.

The average amount of rainfall for each hour during the rainy season has also been calculated by adding together the rainfall for each hour, and then dividing by 2,928. The hour of greatest rainfall is from 4 to 5 p. m. with an average of 0.028 inches. From 3 p. m. to 7 p. m. the average hourly rainfall is above 0.02. The hours of least rainfall are from midnight to 8 a. m. running from 0.002 to 0.004. These hourly figures can be added together to get the average rainfall for any group of hours. For example, the seven hours 10 p. m. to 5 a. m. have only 0.020 inch; while the four hours from 3 p. m. to 7 p. m. have 0.103-inch rainfall.

TABLE 3.—*Average hourly rainfall, probability of rain, probability of thunderstorm, June, July, August, and September, 1905–1928*

Hour ending	Average rainfall	Probability rain, per cent	Probability thunderstorm, per cent	Hour ending	Average rainfall	Probability rain, per cent	Probability thunderstorm, per cent
1 a. m.	0.003	3.3	1.0	1 p. m.	.001	13.3	8.4
2 a. m.	.002	2.8	1.0	2 p. m.	.012	14.8	11.3
3 a. m.	.003	3.3	1.1	3 p. m.	.017	16.3	16.4
4 a. m.	.002	3.1	1.2	4 p. m.	.024	19.2	21.6
5 a. m.	.003	3.5	1.0	5 p. m.	.028	20.9	21.8
6 a. m.	.004	3.7	1.1	6 p. m.	.027	20.3	19.7
7 a. m.	.004	4.0	1.7	7 p. m.	.024	20.4	16.1
8 a. m.	.004	5.5	1.6	8 p. m.	.014	18.8	10.9
9 a. m.	.005	6.0	1.8	9 p. m.	.008	15.4	6.7
10 a. m.	.006	8.0	2.6	10 p. m.	.005	9.3	4.2
11 a. m.	.007	9.2	3.5	11 p. m.	.004	6.7	2.3
Noon	.009	10.9	5.2	Midnight	.003	4.3	1.6

The relative humidity runs usually above 80 per cent during the night, while during the day there is a marked drop. The curve is almost the inverse of the temperature curve, and from noon to 4 p. m. the average relative humidity is between 50 and 60 per cent. (M. W. R., July, 1919, pp. 466–468 and Oct., 1919, p. 710.) This compares very well with afternoon readings in many of the interior cities, and shows that the humidity is rarely oppressive during the rainy season. Although the rainfall is heavy, the sandy character of the soil allows a rapid run-off. There is little standing water and no mud. The moisture taken up into the air is rapidly distributed by

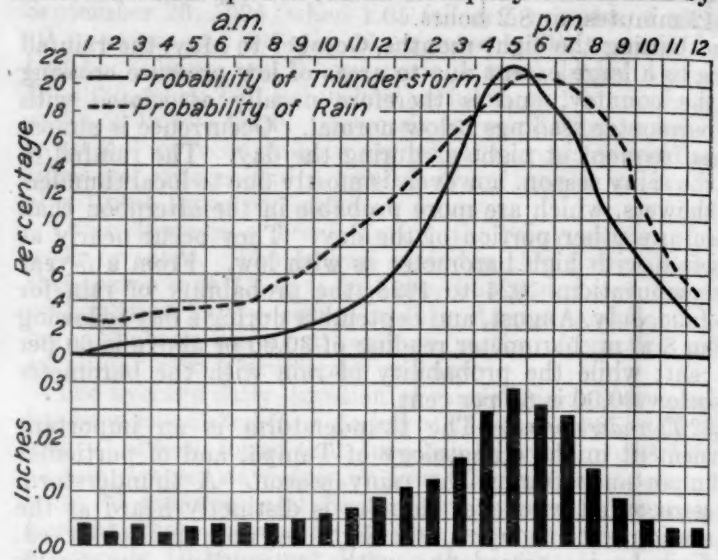


FIGURE 1.—Hourly probability of rain, a thunderstorm and the average precipitation for each hour of the day at Tampa, Fla.

the horizontal air movement and active convection currents, and the humidity is very rarely felt as oppressive

CHANGE IN DENSITY OF SNOW COVER WITH MELTING [1]

By GEORGE D. CLYDE

[Utah Agricultural Experiment Station, Logan, Utah, July 11, 1929]

Measurements of the density of snow have been made in the Sierra Nevada Mountains for many years. At Summit, Calif., measurements of density at foot intervals in depth have been made over a period of five years. These records indicate no uniformity in density in different layers of deep snow. This variability is due to changing weather conditions during the accumulation of snow cover. Ice layers and crusts form at different intervals during the accumulation period. Measurements in California indicate no relationship between density of top layer of snow cover and the lower depths.

During the spring of 1928 a study was made of snow-melting characteristics on the Wasatch Plateau in central Utah. This plateau rises to an elevation of 10,500 feet. The studies were made on the snow cover at elevations of 8,000 to 10,000 feet. Measurements were made to determine the change in density with depth, and it was found that before melting began and while the average density was still increasing with the advance of spring that there was a marked difference in density at different depths due to ice layers and hard crusts. As the spring advanced and daily temperatures rose it was noticed that these hard layers disappeared and the snow cover took on almost a uniform density from top to bottom. On April 26 a snow profile was obtained which clearly indicated these hard layers. The mean temperature on that day was 45.5° F. At the time of observation at 3 p. m., temperature 80° F., water was running along the top of each layer and dripping off at the outcrop. The surface of the snow was melting and the water was seeping down through the snow layer. When this water struck the impervious ice layer it started moving laterally. The temperature of the water being slightly higher than the ice crust it was gradually softened, the snow layer finally taking on a nearly uniform density. Measurements on April 23 showed the presence of ice layers and crusts throughout the snow depth. By April 30 these layers had entirely disappeared. The following table shows the uniformity of density with depth during the melting period.

TABLE 1.—*Snow west of Mammoth Ranger Station (Wasatch Plateau-Manti National Forest, San Pete County, Utah)*

No.	Depth (inches)	Core (inches)	Water content	Density (%)
A. May 10, 1928. After raining all night 8 a. m:				
1	4	30	12.0	40.0
2	12	30	12.2	40.7
3	18	30	12.0	40.0
4	24	30	12.0	40.0
B. May 11, 1928. 7 a. m.*:				
1	3	30	10.0	33.0
2	12	30	12.5	41.6
3	18	30	12.5	41.6
4	24	30	11.5	38.3
C. May 12, 1928. After 63 inches of rain had fallen during the day. 6 p. m.**:				
1	4	30	11.8	39.3
2	12	30	12.0	40.0
3	18	30	12.0	40.0
4	24	30	11.5	38.3

* Froze previous night, causing granulation on top and bottom. Drainage from bottom during freezing reduces density on bottom.

** Snow seems to be same density after rain as before, indicating that rain goes right through.

With the snow melting well under way the density during the day is quite uniform throughout the depth. However, if the measurements are made after the snow solidifies at night, the density will be a little lower at the surface and near the bottom. This is probably due to the draining of the free water from these areas after the snow starts solidifying under the decreased temperatures. This difference in density of the upper and lower layers after freezing becomes more marked as the snow cover gets thinner.

[1] Contribution from Department of Irrigation and Drainage, Utah Agricultural Experiment Station. Publication authorized by Director, July 11, 1929.

The density of new snow will average about 10 per cent. The density of an accumulated snow cover is always greater than this, and it increases with the advance of the season until it reaches a maximum just after the water starts leaving the snow. This lag in maximum density after run-off starts is probably due to difference in rate of melting and rate at which water starts to leave the snow at the bottom.

When the snow cover is deep the surface is granular due to the daily melting and freezing. Below the surface layer the snow is finer textured. Where the layer of snow is thin it is granular all the way down as the effect of daily melting and freezing goes through the entire layer.

The winter precipitation season on the Wasatch Plateau is practically over by April 1. On March 28, 1928, the density of the snow cover was 35.1 per cent, none of the snow having melted. The density gradually increased until by April 23 it had reached 41.2 per cent, with still no evidence of melting. By April 27, the density had increased to 49.4 per cent and the snow cover had lost very little water. The melting began when the density was somewhere around 49 per cent. On April 30 the density reached 50.1 per cent, and the snow cover had lost about 25 per cent of its water. By May 3 the density had fallen to 37.9 per cent, the snow cover retaining only 50 per cent of the water present on April 27. These data indicate an increase in density of the snow cover until shortly after the water starts leaving the snow, after which the density decreases. As the water passes downward through the snow layer the smaller snow particles are melted leaving a more porous structure, having a lower density. The density does not seem to continue to decrease with melting but rather quickly reaches a density between 35 and 40 per cent, where it remains practically constant until the snow cover is entirely melted. Figure 1 shows the variation of density

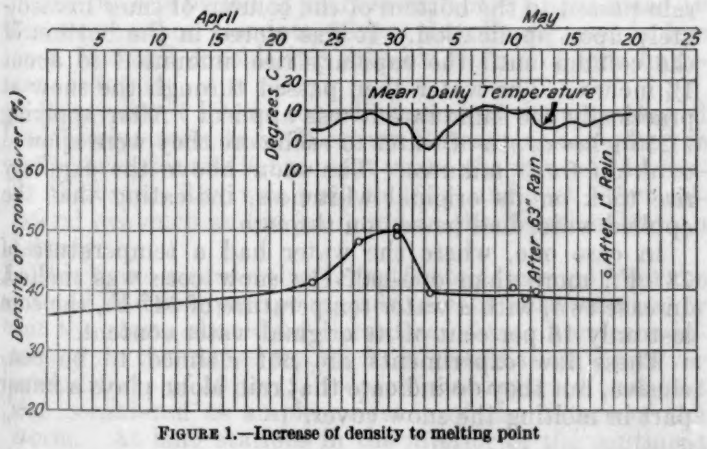


FIGURE 1.—Increase of density to melting point

with the advancing season. It will be noted from this curve that the density started increasing rapidly on April 23.

A continuous temperature record was kept, beginning on April 22. Before this date it was extremely cold. On April 23 the temperature started rising, and for eight days, or until May 1, it remained above freezing night and day. The mean daily temperatures for these days are plotted on Figure 1.

Figure 2 shows an hourly hydrograph of the principal stream in the area studied together with the hourly tem-

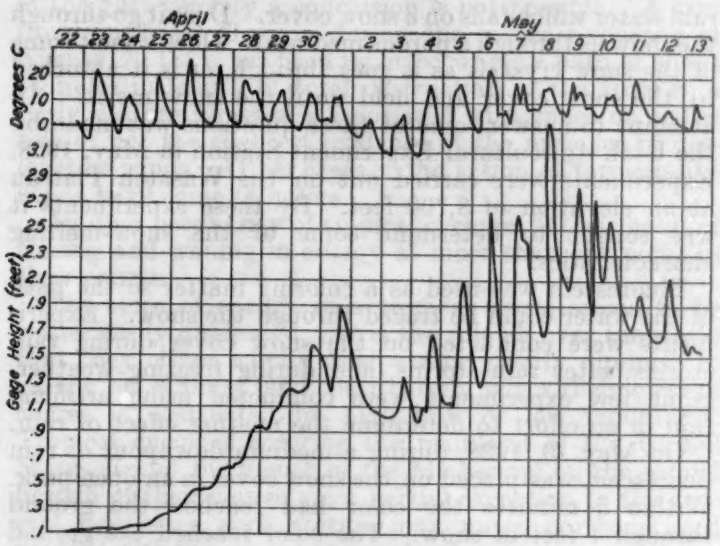


FIGURE 2.—Hourly hydrograph and thermograph at dam site on Gooseberry Creek. Drainage area 6.11 square miles. Elevation, 9,000 feet

NOTE.—Prior to April 22 the temperature was very cold.

peratures. It will be noted that there was an accumulation of 27.7° C. above freezing, before the density reached the point of melting on April 27. By May 1 there had been an accumulation of 55.5 day-degrees[2] C. above freezing. During this period the water content of the snow cover had decreased from 17 to 8.2 inches, or 0.16 inch per day degree C. temperature. From April 27 to April 30 the density increased slightly, but the run-off from the snow cover accelerated rapidly. No precipitation fell during the period April 22 to May 7.

SUMMARY

1. There seems to be no relation between the density of the snow layer at different depths during the accumulation season.

2. After melting begins the ice layers and hard crusts disappear and the snow cover takes on almost a uniform density throughout its depth.

3. The density of a snow cover increases throughout the accumulation season reaching its maximum soon after melting starts.

4. As the melting progresses the density decreases to a point usually between 35 and 40 per cent where it remains nearly constant until snow disappears.

5. Data taken in this single experiment indicate that one day degree C. of temperature is required to melt the snow equivalent of 0.16 inch of water.

[2] One day-degree F. is defined as one degree F. for one day or 24 hours. For example, an average daily temperature of 40 degrees for one day would be the equivalent of 40 day degrees.

THE EFFECT OF RAIN ON THE SNOW COVER[1]

GEORGE D. CLYDE

[Utah Agricultural Experiment Station, Logan, Utah, July 11, 1929]

There are several opinions concerning the disposal of rain water which falls on a snow cover. Does it go through the snow as through a porous medium? Does it melt some of the snow crystals as it goes through, or is it absorbed by the snow cover and held until the snow melts? An attempt to answer some of these questions was made by the Utah Agricultural Experiment Station in May, 1928. Experiments were carried out on the Wasatch Plateau at an elevation of 8,700 feet. By these experiments it was sought to determine some of the snow-melting characteristics.

Fluorescein was used as a coloring matter so the path of the water could be traced through the snow. Experiments were conducted on the snow cover during rain storms, after rain storms, and during freezing weather. Some few experiments were conducted using artificial rain in an effort to determine the melting effect of rain.

On May 10, 1928, during a medium downpour of rain fluorescein was placed on the snow cover in an open park. Within 5 minutes the color had reached the ground through 4 feet of snow. The color reached the ground first through tiny crooked paths, indicating there were continuous paths through which the rain water was reaching the ground. The entire mass of snow showed the color more slowly, indicating that a general downward movement of water through the snow was going on.

Fluorescein placed on a level snow surface during clear, warm weather showed some well defined water channels, but in general the downward movement of moisture was quite uniform throughout the entire mass. This indicated that the snow layer was melting from the top as well as from the bottom and that the water from the surface was going down through the porous snow to the ground.

Fluorescein was placed on a level snow surface just prior to freezing temperature. In fact, the thermometer registered quite close to zero centigrade when the color was placed. Twelve hours later the snow column was examined, and it was found that the color had progressed only approximately 3 inches into the snow, showing that with the fall in temperature the water in the snow, which carried the color, was congealed and held in place until higher temperatures melted it again.

Along with this experiment fluorescein was placed on a snow cover on a steep slope to determine if any degree of movement took place down the slope. In the first case the slope was one and one-half to one. The color moved down the slope only 1½ feet, while dropping vertically approximately 3 feet. This indicates that there is not much movement of moisture down the slope through the snow cover. In the second case the slope was flatter, being two to one, in which the color passed vertically downward and then moved along the ground in the snow layer next to the ground about 3 feet in 12 hours. There was no appreciable lateral movement through the snow. The third case was a repetition of the first, on a slope of one and one-half to one, and here the coloring matter moved down the slope about a foot in a vertical drop of 3 feet. These experiments indicate very little movement down the slope through the snow during the process of melting.

In addition to the above field experiments some laboratory experiments were conducted using snow cores 8 inches in diameter and up to 20 inches long. These core were allowed to melt under a constant temperature of 90° F. Fluorescein was placed on each core, and in every case narrow streaks of color preceded the uniform mass of color to the bottom. The coloring matter had entirely disappeared from the snow before the cores were entirely melted, showing that the water carrying the coloring matter had entirely passed out of the snow cores.

To determine the extent to which rain melts the snow cover on which it falls, two snow cores having a diameter of 6.37 inches and depth of 7.25 inches were set up. Colored artificial rain water was applied to these cores through a hand sprinkler. The temperature of water on first core was 78° F. and on the second core 54° F. Water to a depth of 7 inches was sprinkled on each core. Both cores had passed their point of maximum density and the snow was granular and porous. The artificial rain passed to the bottom of the column of snow immediately upon application. It was stored in the bottom of the column until the capillary rise amounted to about 1¼ inches. The water then passed through the snow at practically the same rate it was applied. After applying 7.25 inches depth of water to each core they were allowed to drain for 3 minutes. The snow above the capillary rise took on its original whiteness, indicating that the applied water had passed on through.

In case one, where the water had a temperature of 78° F., more than one-half the snow core was melted. In case two, with a water temperature of 54° F., the core lost only 18 per cent of its original water content.

These few experiments are not claimed to be conclusive, but they do indicate that rain alone plays a minor part in melting the snow cover.

[1] Contribution from Department of Irrigation and Drainage, Utah Agricultural Experiment Station. Publication authorized by Director, July 11, 1929.

THE FREQUENCY OF TROPICAL CYCLONES (WEST INDIAN HURRICANES) THAT CLOSELY APPROACH OR ENTER CONTINENTAL UNITED STATES

By ALFRED J. HENRY

Although there have been three major compilations of the purely statistical view of tropical cyclones of the Western Hemisphere during the last twenty and odd years[1] close agreement in the number and frequency of these storms is lacking. This is not surprising in view of the inherent difficulty that arises when attempt is made to use a scale of intensity. No two persons will closely agree upon the allocation of a large number of storms to any common scale. The beginning of the record in each of these publications is different; the storms of the early seventies being omitted, thus: Garriott begins with 1878 and ends with 1900, Fassig begins with 1876 and ends with 1911, and Mitchell begins with 1887 and ends with 1923. While it is true that the record of the early seventies is much less complete than that of subsequent years, nevertheless it is the purpose of the present writer to include it to the end that the record of tropical cyclones

[1] Garriott, E. B., West Indian Hurricanes, Weather Bureau Bulletin H, Washington, D. C., 1900. Fassig, O. L., Hurricanes of the West Indies, Weather Bureau Bulletin X, 19193. Mitchell, C. L., West Indian Hurricanes and Other Tropical Cyclones of the North Atlantic, Mo. Wea. Rev., Supplement No. 24, 1924.

during the life of the Federal weather service may be complete and homogeneous. It developed at the beginning of the study that it would be necessary to examine the entire record of 58 years to insure homogeneity. Considerable difficulty was encountered because of the fact that it was not always possible to distinguish from the printed records between those storms which might be classed as severe tropical cyclones and those that did not possess the distinctive features of a severe tropical storm.

Mitchell realized this necessity and classed the storms listed into three groups as follows: (1) Those of known hurricane intensity, 122 or 51 per cent; (2) doubtful, 57 or 24 per cent; (3) not of hurricane intensity, 60 or 25 per cent. His criterion of intensity was a wind velocity of at least 60 m. p. h. I have adopted this criterion and added two others, first a minimum pressure of at least 29.50 inches, sea level and second the origin of the storm must have been below the parallel of 30° north latitude, so that roughly speaking, a storm must have had a minimum pressure of half an inch below normal sea level pressure and a velocity equal to force 10 to 12 Beaufort scale and have originated below 30° north latitude. Using the criteria first named (1 and 2) many extra tropical cyclones would qualify. The third criterion seems necessary to establish the right to be classed as a tropical cyclone.

The result of applying these tests to the data in hand was to reduce, somewhat, the number of tropical cyclones hitherto reported as having visited continental United States or having approached close enough thereto to warrant the display of storm warnings along the Atlantic seaboard. Following is a comparison with the figures previously reported: Garriott listed 95 storms during the 23 years 1878–1900, Fassig listed 143 storms during the 36 years 1876–1911, Mitchell listed 239 storms during the 37 years 1887–1923. The last named, however, classed as true hurricanes but 122 out of his total of 239 storms.

For the like period of years in each case I have listed 19 less storms than Garriott, 38 less than Fassig, and 14 less than Mitchell considering only his storms of true hurricane intensity.

In my count I have consulted some of the unpublished manuscript records of Weather Bureau stations for the early seventies and subsequent years, the printed MONTHLY WEATHER REVIEWS back to 1873, and such other collateral evidence as can be found in the Weather Bureau Library.

It is by no means a simple matter to determine from the printed and manuscript records in each case whether or not the storm should be classed as of true hurricane intensity; in the case of reports from vessels at sea whenever a wind force of 10 to 12 Beaufort was reported that fact was considered as ample evidence of the nature of the storm. At land stations in the interior of the continent at some distance from the storm center it was necessary to consider the evidence of destructive wind force as manifested in the damage and destruction of buildings and the blowing down and twisting off of trees near the ground.

During the course of the study evidence of the twisting character of the winds in a few severe storms was found. The almost total destruction of substantially built structures in Porto Rico during the prevalence of the hurricane of September 10–20, 1928, as shown by photographs exhibited to the writer by Doctor Fassig, during his recent visit to Washington, D. C., raises a reasonable doubt as to whether the destruction was due to a steady blow or to shifting gusts from varying directions; since however no measures are available as to either the force or direction of the gust velocity a conclusion is not possible. A case from southeast Georgia during the severe hurricane of August 28, 1881, has been reported where a path of about 16 miles in length of total destruction of the trees in a fairly mature forest was associated with zones on either side of not the slightest evidence of the presence of destructive winds. Other cases of the action of tornado-like winds have come to notice.

Another peculiarity of tropical cyclones is their habit of waxing and waning in energy at more than one point in their course.

The store of energy in a tropical storm seems to be rather easily dissipated. It is the rule all over the world that they either wholly dissipate or greatly diminish in energy on striking land, particularly when their onward course is obstructed by high hills or low mountains. Tropical cyclones entering the mainland of the United States east of the mouth of the Mississippi on the second branch of their course are a partial exception to the general rule since such storms may move northeastward parallel with the coast but over land and retain a measure of the intensity of a true hurricane; several cases are known of the central calm area persisting to and above the parallel of 40° north latitude. The residual depression that sometimes persists after striking the coast may reach the lake region and there merge in the general easterly drift in that region. A notable exception to all rules is the case of the tropical cyclone of September 28–29, 1896. In the morning of the 28th it was centered over southeastern Georgia with a central isobar of 20.70 inches. Its previous history was somewhat obscure but it was later tracked to about W. long. 65°. During the daylight hours of the 28th the cyclone moved rapidly northward, pressure at its center decreasing about half an inch; it was not associated with much heavy rainfall but hurricane winds developed by nightfall, a maximum velocity of 66 m. p. h. being recorded at Washington, D. C. One person was killed by falling walls in Washington and 113 elsewhere, mostly in Florida and Georgia. The property loss aggregated about $7,000,000.

In Table 1 I give the number of tropical storms that have been reported as having entered or approached the Continent of North America from tropical seas each year from 1871 to 1928. The well-known list of Poey was used, after storms of undoubted extra-tropical origin had been deleted. The inclusion of these storms in the original list seems to have been due to the fact that they were reported by W. C. Redfield, the pioneer student of tropical cyclones in the Western Hemisphere. Redfield in his effort to establish the rotary character of storms drew his examples from both tropical and extra-tropical storms and his listing of a storm was not questioned. It is clear from a reading of his original papers that he never distinguished between the two classes of storms.

I have supplemented Poey's list so as to bridge the gap between 1855 and 1870, both inclusive, from various sources as indicated.

TABLE 1.—*Chronological list of tropical cyclones that approached or touched the United States, 1722 to 1870*

[Abstracted from Table chronologique de quatre cents cyclones qui ont sévi dans les Indes Occidentales et dans l' Océan Atlantique Nord depuis 1493 jusqu'en 1855, by Andrès Poey, 1862, with additions. Intensity of storms mostly indeterminate]

Dates	Localities	Authorities
Aug. 28, 1722	Jamaica, Carolinas	Schomburgk[1] Edwards,[2] vol. 1, p. 197; Tegg,[3] pp. 149, 157; Rees's Encyclopedia (article on "Hurricane"); Evans [4]; Johnston [5]; Southey,[6] vol. 2, p. 231; Robert Renny, History of Jamaica, p. 48, London, 1807; G. W. Bridges, Annals of Jamaica, p. 352, London, 1828; Henderson, Almanac of Jamaica, p. 34, 1852; Moreau de Jonnès' [7]; Aikman's Almanac, p. 24, Jamaica, 1816.
August, 1728	Carolinas	Redfield's MSS.; Tegg,[3] p. 157.
September, 1752	Charleston, S. C	Redfield's MSS.
Sept. 15, 1752	do	Blodgett, Climatology, p. 397.
Sept. 15, 1753	Charleston, S. C	Tegg,[3] p. 134.
1756	Coast Georgia, St. Simons Island.	Lyell (second visit to United States).
1757	Florida to Boston, Mass.	Warden,[8] vol. 1, p. 155.
Aug. 23, 1758	Barbados, South Carolina.	Tegg,[3] pp. 157, 162.
May 4, 1761	Charleston, S. C	Tegg,[3] p. 157.
June 1, 1761	do	Phillips, Barbados Almanac, 1839, p. 123.
Sept. 11, 1766	Virginia	Redfield's MSS.
Oct. 22, 1766	Pensacola, Fla	Schomburgk [1]; Southey,[6] vol. 2, p. 390; Evans [4]; Johnston.[5]
Aug. 30, 1769	East of Florida	Redfield's MSS.
Oct. 20, 1769	do	Bernard, Histoire du Roman; Redfield's MSS.; Tegg,[3] p. 132.
June 6, 1770	Charleston, S. C	Perrey. (NOTE.—Name of publication not given.)
Aug. 31–Sept. 3, 1772	Southern Louisiana along the coast.	Blodgett, Climatology, p. 397.[15]
August, 1773	Boston, Mass	Tegg,[3] p. 157.
1779	New Orleans, La	Dunbar, Transactions of the American Society, Philadelphia, vol. 6, second series. Philadelphia, 1804.
Oct. 7–10, 1778	New Orelans, La. (near).	Blodgett, Climatology, p. 397.[15]
Aug. 18, 1779	do	Do.
Aug. 25, 1780	St. Kitts, New Orleans, La.	Dunbar, idem.; Redfield's MSS.
Oct. 3–5, 1780	Gulf of Florida	Blodgett, Climatology,[15] p. 397.
Oct. 10–18, 1780	Barbados, Jamaica, Havana.	Blodgett, Climatology, p. 397, The Great Hurricane of 1780.
Aug. 10, 1781	North Carolina	Redfield's MSS.
Sept. 22–24, 1785	Carolinas and Virginia.	New Haven Gazette, Oct. 13.
Aug. 29, 1786	United States	Pennsylvania Packet, Philadelphia, Jan. 22, 1787.
July 30, 1787	do	Redfield's MSS.
Aug. 15, 1787	Florida	Do.
Sept. 19, 1787	United States	Do.
July 22, 1788	do	Do.
Aug. 19, 1788	do	Do.
Sept. 19, 20, 1788	do	Do.
September, 1797	Charleston, S. C	Blodgett, Climatology,[15] p. 397.
Sept. 3–9, 1804	Martinique, islands of the Caribbean Sea, coast South Carolina and Georgia.	Schomburgk[1]; Edwards[2]; Warden,[8] vol. 1, p. 155; Purdy,[9] p. 102; Mease, Geological Account of the United States, p. 100; Medical Repertory, Hex., vol. 1, and Hex. II, vol. 2, p. 354; Evans [4]; Moreau de Jonnès [7]; Redfield, Route IV.[16]
Oct. 4, 1804 *	Savannah, Ga	Redfield's MSS.; Burr's Letters.
Oct. 9, 1804 *	United States	Redfield's MSS.; New York Herald, Oct. 24.
Sept. 10, 1811	Charleston, S. C	Blodgett, Climatology,[15] p. 398—Very violent.
Aug. 19, 1812	New Orleans, La	Redfield's MSS.
Aug. 27, 1813	Charleston, S. C	Blodgett, Climatology,[15] p. 398.
July 1, 1814	do	Do.
Sept. 18–24, 1815	Coast New York and New England.	Do.
Sept. 1, 1821	Turks Island to Long Island.	Schomburgk;[1] Purdy,[9] p. 102; Reid,[10] pp. 11–15, Chart I; Espy,[11] pp. 209–228; Evans;[4] Johnston;[5] Redfield, Silliman's Journal (The American Journal of Science and Arts), 2d series, vol. 20, pp. 24–27; Redfield;[12] Redfield, Route VIII.[16]
Sept. 25, 1821 *	New Haven, Conn	Tegg,[3] p. 159.
July 11, 1822	Mobile, Ala	New York Gazette; Redfield's MSS.
1824	Coast of Georgia	Blodgett, Climatology,[15] p. 398.
July 30, 1827	North Carolina	Perrey. (NOTE.—Name of publication not given.)
Aug. 17–28, 1827	Windward Islands to Porpoise Bank (37° 43′ N., 75° 21′ W.).	Schomburgk;[1] Purdy,[9] p. 98; Evans;[4] Almanach de Saint-Christophe; Perrey (see note immediately above); Redfield;[12] Redfield, Route III.[16]
July 24, 1829	Boston, Mass	Purdy,[9] p. 98; Thomson,[13] p. 416; Boston Gazette.
Aug. 19–24, 1830	Martinique	Purdy,[9] p. 102; Reid,[10] pp. 127–132.
Aug. 10–19, 1830	United States coast, Florida to Norfolk, Va.	Blodgett, Climatology,[15] p. 398.
Sept. 29–Oct. 2, 1830	West Indies to Grand Bank.	Do.[15]
June 10, 1831	Florida	Redfield's MSS.
Aug. 10–17, 1831	Gulf coast	Redfield, Track II.
September, 1834	Mouth of Rio Grande	Blodgett, Climatology.[15]

* Probably a duplicate.

TABLE 1.—*Chronological list of tropical cyclones that approached or touched the United States, 1722 to 1870*—Continued

[Abstracted from Table chronologique de quatre cents cyclones qui ont sévi dans les Indes Occidentales et dans l' Océan Atlantique Nord depuis 1493 jusqu'en 1855, by Andrès Poey, 1862, with additions. Intensity of storms mostly indeterminate]

Dates	Localities	Authorities
Aug. 12–18, 1835	Antigua, Cuba, Galveston.	Redfield, Route V;[12] Schomburgh;[1] Piddington,[14] p. 144; Reid,[10] p. 43; Evans;[4] Johnston.[5]
Aug. 31, 1837	St. Mark, Fla	Redfield;[16] Reid,[10] pp. 119–124.
Aug. 31–Sept. 3, 1837.	Apalachicola, Fla	Reid,[10] pp. 124, 126.
Sept. 27–Oct. 10, 1837.	Gulf of Mexico	Reid,[10] pp. 133–145; Reid,[13] pp. 13, 209; Piddington,[14] p. 144; Redfield, Route XV.[16]
Nov. 5, 1839	Galveston, near St. Louis Island, Gulf of Mexico.	Evans.[4]
Oct. 3–6, 1841	Nantucket	Royal Gazette, Bermuda, Oct. 26; New York Journal of Commerce, Oct. 11.
Aug. 30–Sept. 9, 1842.	Due west across Florida to Tampico.	Blodgett, Climatology,[15] p. 399.
Oct. 2–9, 1842	Gulf of Mexico, Atlantic coast south of Charleston.	Do.[15]
July 12, 1842	Ocracoke, Cape Hatteras, N. C.	Evans;[4] Johnston.[5]
Oct. 13, 1843	Florida	Moniteur Belge, Oct. 26.
Aug. 4–6, 1844	Mouth of Rio Grande	Blodgett, Climatology,[15] p. 399.
Oct. 4–7, 1844	Cuba, Key West, Charleston.	Do.[15]
Oct. 12, 1845	Florida Channel	Johnston;[5] Evans.[4]
Oct. 6–18, 1846	Cuba, United States	Desiderio Herrera. Memoria sobre los Huracanes en la Isla de Cuba. Habana, 1847; Schomburgk;[1] Redfield, Route XX;[16] Piddington,[14] pp. 134, 193, 195; Royal Gazette, Bermuda, Oct. 20, Nov. 3, 17, and 24; Thomson,[13] p. 419; Reseña de los Estragos del Huracan de 1846; Piddington,[17] p. 155; New York Daily News, Dec. 21; New York Evening Mail, Nov. 6; Mission Record, vol. 2, p. 19; Diario de la Habana, Oct. 15, 20; Moniteur Belge, Nov. 22.
Aug. 22–Sept. 5, 1848.	Off Florida coast	12—Track XXI.
Aug. 16–28, 1851	St. Mark, Fla., St. Kitts, St. Thomas, Cuba.	Almanach de Saint-Christophe, 1855; New York Herald, Oct. 23; Royal Gazette, Bermuda, Sept. 2; Indépendance Belge, Sept. 28; Redfield, Route XXII.[16]
Oct. 9, 1852	St. Mark, Fla	New York Herald, Oct. 20 and 23.
Aug. 30–Sept. 11, 1853.	Cape Verde, Hatteras, N. C.	Redfield, Route XXIV;[16] Redfield.[16]
Sept. 6–14, 1854	Atlantic coast, Florida to New England.	Blodgett, Climatology [15] U. S., p. 400.
Aug. 10, 1856	Louisiana coast	Blodgett, Climatology,[15] p. 400. This was the storm celebrated in story by Lafcadio Hearn in "A memory of Last Island." The Warner Library, Harper Bros., vol. 12, p. 7, 132.
Aug. 2–Sept. 2, 1856.	Gulf coast and thence northeast.	Blodgett, Climatology,[15] p. 400.
Oct. 22, 1865	Calcasieu, La., coast	Mo. Wea. Rev., 49:456. Lowest barometer at Habana, 28.78 in.
Oct. 2–3, 1867	Galveston-Virgin Islands.	Mo. Wea. Rev.,[20] 49:456 and Bulletin H, H. p. 58.
Oct. 19–20, 1870	Pinar del Rio	Wea. Bu. Bulletin H,[19] p. 58. Lowest barometer, Habana, 29.32 in.
Oct. 7–8, 1870	Habana-Matanzas	Lowest barometer,[19] 29.38, Wea. Bu. Bull. H, p. 58.

REFERENCES

[1] Schomburgk, Sir Robert. History of Barbados, pp. 38–62 and 689–695. London. 1848.
[2] Edwards. History of the West Indies, 4th edition, vol. 1. London. 1805.
[3] Tegg's Chronology. London. 1824.
[4] Evans, Lieut. R. N. A Chronological List of the Hurricanes Which Have Occurred in the West Indies Since the Year 1493. London Nautical Magazine, 1848, pp. 397, 453, and 524.
[5] Johnston. Physical Atlas, new edition, p. 6. Edinburgh. 1855.
[6] Southey, Capt. Thomas. Chronological History of the West Indies. London. 1827.
[7] Moreau de Jonnès. Histoire Physique des Antilles Francaises, vol. 1, p. 346. Paris. 1822.
[8] Warden. A Statistical, Political, and Historical Account of the United States of America. Edinburgh. 1819.
[9] Purdy. Northern Atlantic Ocean, 7th edition. London.
[10] Reid. An Attempt to Develop the Law of Storms by Means of Facts Arranged According to Place and Time, 3d edition. London. 1850.
[11] Espy. Philosophy of Storms. Boston. 1841.
[12] Redfield. On Gales and Hurricanes of the Western Atlantic. U. S. Naval Magazine, 1836, vol. 1, and London Nautical Magazine, 1836, vol. 5, p. 199. Silliman's Journal. (The American Jour. of Sci. and Arts.)
[13] Thomson. Introduction to Meteorology. London. 1849.
[14] Piddington. The Sailor's Horn-book. New York. 1848.
[15] Reid. Progress of the Development of the Law of Storms and of the Variable Winds. London. 1849.
[16] Redfield. Cape Verde and Hatteras Hurricane of August–September, 1853, with a Hurricane Chart, etc. The American Journal of Science and Arts, vol. 18, 2d series New Haven. 1854. Annals of Science, vol. 2. Cleveland. 1854.
[17] Piddington. The Sailor's Horn-book for the Law of Storms, 2d edition. London. 1851. Translated and arranged by W. W. R.
[18] Blodgett, L. Climatology of United States.
[19] Weather Bureau Bulletin H, West Indian Hurricanes, E. B. Garriott, Washington, 1900.
[20] MONTHLY WEA. REV.

TABLE 2.—*Frequency of tropical cyclones (West Indian hurricanes), 1871–1928*

Year	June	July	August	September	October	November	Total*	Smoothed numbers
1871	1 (?)		2		1 (?)		4 (?)	
1872							0	1.5
1873			1		1		2	1.2
1874				1			1	1.2
1875				1			1	1.2
1876				1	1		2	2.0
1877				2	1		3	2.7
1878				1	2		3	2.7
1879			1		1		2	2.5
1880			3				3	2.5
1881			1	1			2	2.2
1882				1	1		2	2.5
1883			2	1	1		4	3.0
1884				1	1		2	2.5
1885			1	1			2	3.5
1886	2		4	1	1		8	6.5
1887			3	3	2		8	7.7
1888			1	3	2	1	7	6.7
1889			1	2	2		5	4.5
1890			1				1	4.2
1891		1	2	3	4		10	6.0
1892			1	1	1		3	6.2
1893	1	1	4	1	2		9	6.5
1894			1	1	3		5	5.0
1895					1		1	2.7
1896		1		3			4	2.2
1897							0	1.7
1898			1	2			3	2.2
1899			1	1	1		3	2.5
1900				1			1	2.0
1901		1	2				3	2.0
1902					1		1	2.2
1903		1	1	2			4	3.2
1904				1	2	1	4	3.5
1905				1	1		2	2.7
1906				2	1		3	2.0
1907							0	1.5
1908		1		2			3	2.5
1909		1	1	1	1		4	3.2
1910				1	1		2	2.2
1911			1				1	1.7
1912				1	1	1	3	1.7
1913							0	0.7
1914							0	0.7
1915				3			3	4.0
1916		3	4		2	1	10	6.2
1917				2			2	4.2
1918			1	2			3	2.5
1919				2			2	2.2
1920				2			2	2.7
1921	1			3	1		5	4.5
1922			3	2	1		6	5.2
1923				3	1		4	4.7
1924			2	1	1	1	5	4.2
1925			1	1		1	3	4.2
1926		1	2	2	1		6	4.0
1927			1				1	3.0
1928			3	1			4	
Sum	5	11	53	68	44	6	187	

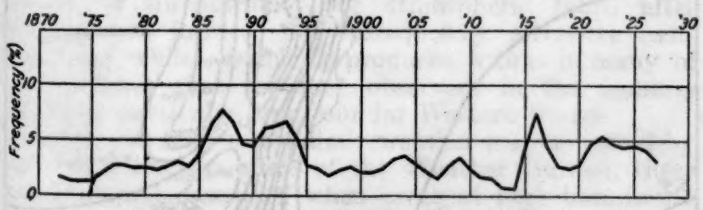


FIGURE 1.—Frequency of tropical cyclones, 1871–1928

I have plotted the smoothed annual number in Table 2 to form the curve in Figure 1. The smoothing process $\frac{(a+2b+c)}{4}$ tends to shift the epochs of maximum or minimum a year, or more, in extreme cases ahead or behind the true date and to reduce the amplitude of the oscillations from year to year; thus the greatest number of storms in any one year occurred in 1891 and 1916. In the first named the maximum was preceded by a year with but a single storm and followed with a year having but three, hence the smoothed value comes out as seven and the year of maximum for the three years is displaced forward to 1893. The chief maximum, 3-year periods considered, occurred in 1886–1888, but the total number of storms in any one of these years was not so great as in 1891 or 1916. There also seems to have been a secondary maximum in the three years 1921–1923. No storms of hurricane intensity occurred in 1907, 1913, and 1914.

DISCUSSION

By Dr. O. L. FASSIG

One interesting result of your list is fixing the culmination of the storm period in September, with August and October nearly equal in storm frequency and again July and November.

I have just completed a study of hurricanes affecting Porto Rico. The results are shown in the accompanying chart (fig. 2). You will see that our storms are also decidedly most frequent in September. I have endeavored to classify Porto Rican storms on a basis of intensity as affecting Porto Rico—dividing them into three classes. Class A includes all storms whose centers passed directly

YEAR \ MONTH	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL
1899								A	C				2
1900								C	C				2
01							C						1
02	INTENSITY												
03	CLASS A - GENERALLY DESTRUCTIVE.												
04	CLASS B - LOCALLY DESTRUCTIVE WITH												
05	BENEFICIAL RAINS.												
06	CLASS C - LIGHT LOCAL LOSSES WITH								B				1
07	BENEFICIAL RAINS.												
08	CLASS A, 10%								C				1
09	CLASS B, 30%							B					
10	CLASS C, 60%								B				
11													
12													
13													
14													
15								B					1
16								B		C			2
17									C				1
18													
19									C				1
20													
21									C				1
22									C				1
23													
24								C					1
25													
26							B		C				2
27													
28									A				1
SUMS							2	6	11	1			20
MEANS	(% OF TOTAL ANNUAL)						10	30	55	5			

FIGURE 2.—Distribution of tropical cyclones in Porto Rico

over the island and embraced the entire island within the central area of hurricane winds; of this class there were only two in 30 years, namely 1899 and 1928. Class B, numbering six storms, includes all storms in which some portion of Porto Rico was within the area of hurricane winds—i. e., winds of 75 miles or more per hour. In Class C, Porto Rico fell entirely outside the central area of hurricane winds, but within the area of moderately high winds accompanied by heavy rains. Class C may be called beneficial hurricanes, as the economic value of the rainfall far exceeded all losses by wind.

During the period from 1899 to 1930, Porto Rico had 2 overwhelmingly destructive storms; 6 storms with heavy local losses, combined with beneficial general

rains; 11 storms causing insignificant losses by wind compared with the great benefits to crops and municipal water supplies.

The historic storms of August 8, 1899, and September 13, 1928 (known respectively as San Ciriaco and San Felipe) occurred at the beginning and at the end of the 30-year period. The storms of secondary destructive force (class B) occurred as follows: July, 1926; August, 1909, 1915, 1916; September, 1906, 1910.

An inspection of the accompanying chart (fig. 2) showing the time distribution of hurricanes of Porto Rico will show that the 12 "beneficial" hurricanes (class C) comprise 60 per cent of the total number of cyclonic storms recorded in the past 30 years; that 6, or 30 per cent (class B) seriously affected only certain portions of the island and that 2, or 10 per cent (class A) brought not only general destruction to crops and homes, but involved heavy loss of life.

Combining all classes we have 10 per cent of the storms occurring in July, 30 per cent in August, 55 per cent in September, and 5 per cent in October. The period of 30 years is too short to give these percentages a dependable value, they may however be regarded as rough measures of frequency and intensity for Porto Rico.

We may disregard class C as a cause for alarm. Considering only classes A and B: (*a*) There has been no single year with more than one storm; (*b*) the 6-year period 1900 to 1905, the 4-year period 1911 to 1914, and the 9-year period 1917 to 1925 were without storms of even moderate violence.

THE WEST COAST ATMOSPHERIC FAULT[1]

By EDWARD H. BOWIE

[Weather Bureau, San Francisco, Calif., July 29, 1929]

Meteorologists have heard often and read much in recent years of surfaces of discontinuity in the earth's atmosphere. The Bjerknes school of meteorology has done much to bring them to the attention of meteorologists and to define their significance in the causation of our major atmospheric phenomena.

The Bjerknes school of meteorologists asserts that all of our cyclones occur on the discontinuities that intersect the earth's surface. Of these there are three major ones—(1) that separating the lower stratum, the troposphere, from the upper stratum, the stratosphere; (2) the boundary between the trades and the antitrades of the Tropics; and (3) the so-called "polar front" of the middle latitudes.

To these might well be added that seeming surface of discontinuity separating the trade-wind system of the Northern Hemisphere and that of the Southern Hemisphere. This one undergoes large variations in

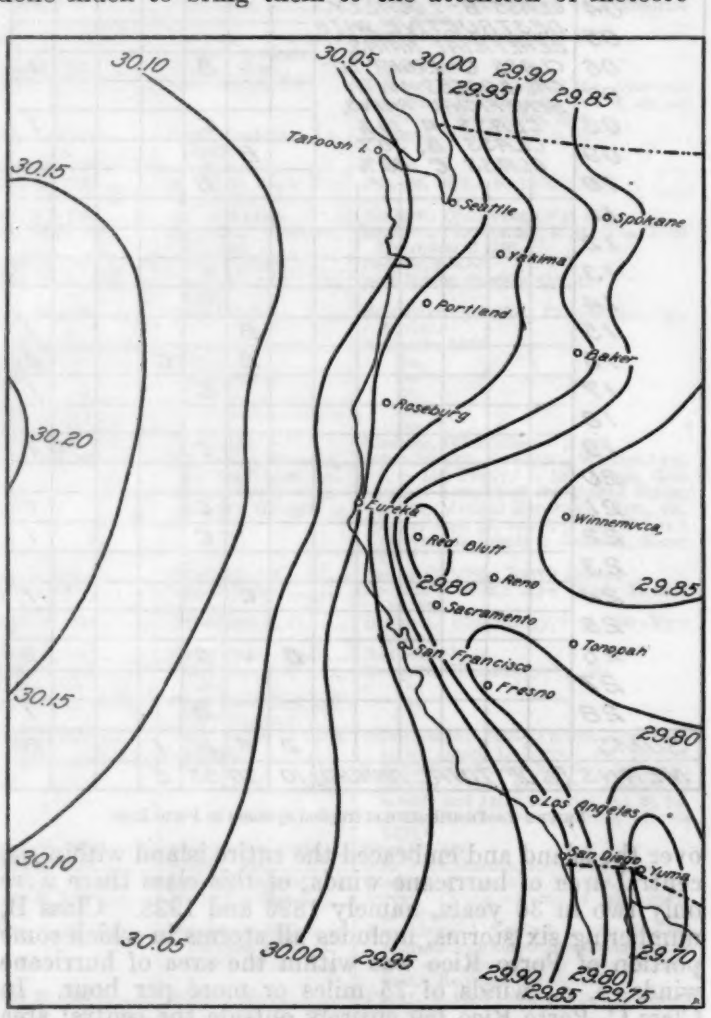


FIGURE 1.—Average sea-level pressure at 5 p. m. third decade of July

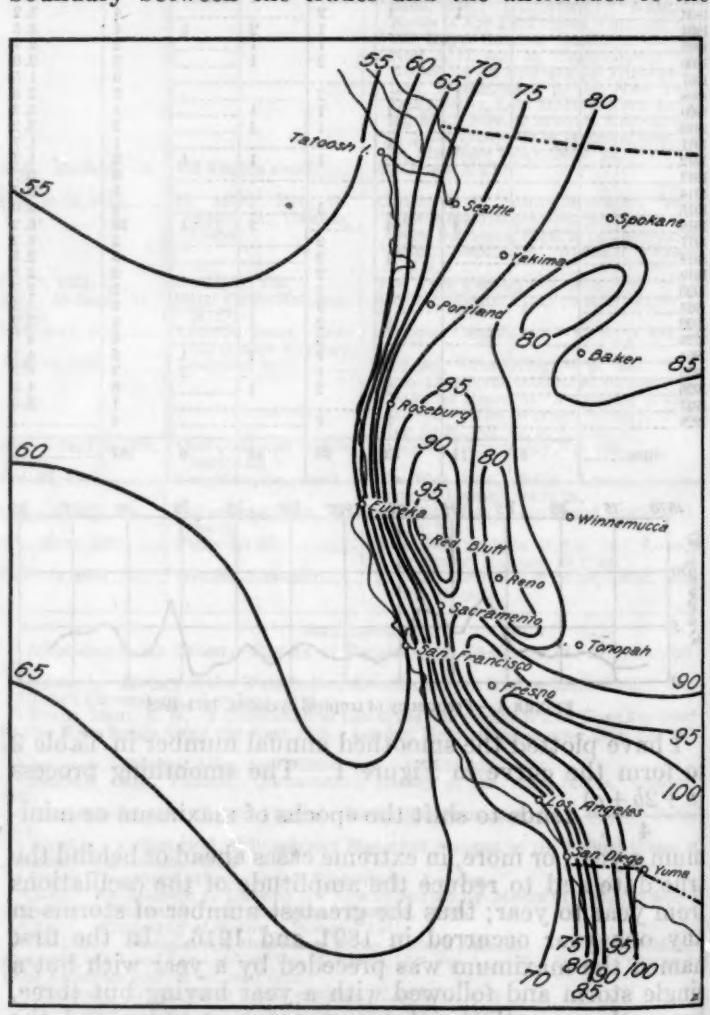


FIGURE 2.—Average air temperature at 5. p. m. third decade of July

[1] Presented before the meeting of the American Meteorological Society at Berkeley, Calif., June, 1929.

definition and geographical location, but it is confined to those regions of the doldrums that are described as centers of maximum frequency of occurrence of tropical cyclones. One of these is located on the Atlantic in the vicinity of the Cape Verde Islands, a second in the western part of the Caribbean Sea, and a third off the west coast of Central America and Mexico. Yet another may be found extending from the vicinity of Guam westward to the Philippine Islands, and still another over the Indian Ocean. No doubt the surfaces of discontinuity that intersect the surface on which the atmosphere rests are breeding places of cyclonic and other disturbances, but it does not necessarily follow that all such that intersect the earth's surface are breeding places of cyclones. Nevertheless, they are all places where contrasts in temperature, humidity, pressure, and wind direction and velocity, both in the horizontal and the vertical, are found.

These surfaces of discontinuity may be likened to atmospheric faults. They are counterparts, in a sense, of geological faults. Thus, if we bring together masses of polar and tropical air, these air strata fail to fit just as would be the case were two geological specimens from different parts of a stratified rock placed side by side. The reference to a surface of discontinuity as an atmospheric fault was, I believe, first made by Dr. G. C. Simpson, director of the British Meteorological Office, in an address on The New Ideas in Meteorology before the British Association, Section A, Southampton, 1925.

I assume that few of us realize that one of the most interesting of meteorological situations in respect to surfaces of discontinuity exists along our western coast. I have referred to this in the title of this paper as The West Coast Atmospheric Fault. It is notably defined in our warm summer months. The two masses of air involved in its formation are (a) the hot, dry air of the interior of the Far West and (b) the cold, humid air of the waters off our western coast. That this surface of discontinuity is a real one is wholly demonstrable. It is not always in evidence, but once having been obliterated it re-forms very quickly. Moreover, this surface of discontinuity, or atmospheric fault, after having once formed, not infrequently advances eastward and while advancing produces within it many of our cyclones that are first observed, in the summer season in particular, over our far Western States.

If you will refer to the daily weather map as issued by the San Francisco office of the Weather Bureau, there will be found occasions when areas of high barometric pressure pass inland from the Pacific Ocean by way of Washington, Oregon, and British Columbia and bring about uniform but high barometric pressure over our Northwestern States, the western Canadian Provinces, the northeast Pacific Ocean. At such times there is also more or less uniformity in temperature of the surface air over these parts of our continent and the waters of the Pacific Ocean adjacent thereto. At the same time the barometer remains low over the Gulf of California, and the upper air winds to considerable heights along the coast are from the north. Subsequently the air that has drifted on to the continent from the ocean has its temperature raised very sharply and rapidly by the radiation of heat to it from the earth's surface, and very quickly thereafter a marked temperature gradient is established between the ocean and the land. As this marked temperature gradient is established, the air pressure falls and the surface and upper air winds change their directions and speed. At such times the center of low barometer over the Gulf of California remains fixed in position, but to the north and northwest of it the barometer falls steadily and progressively even as far north as British Columbia. When the latter area (British Columbia) is

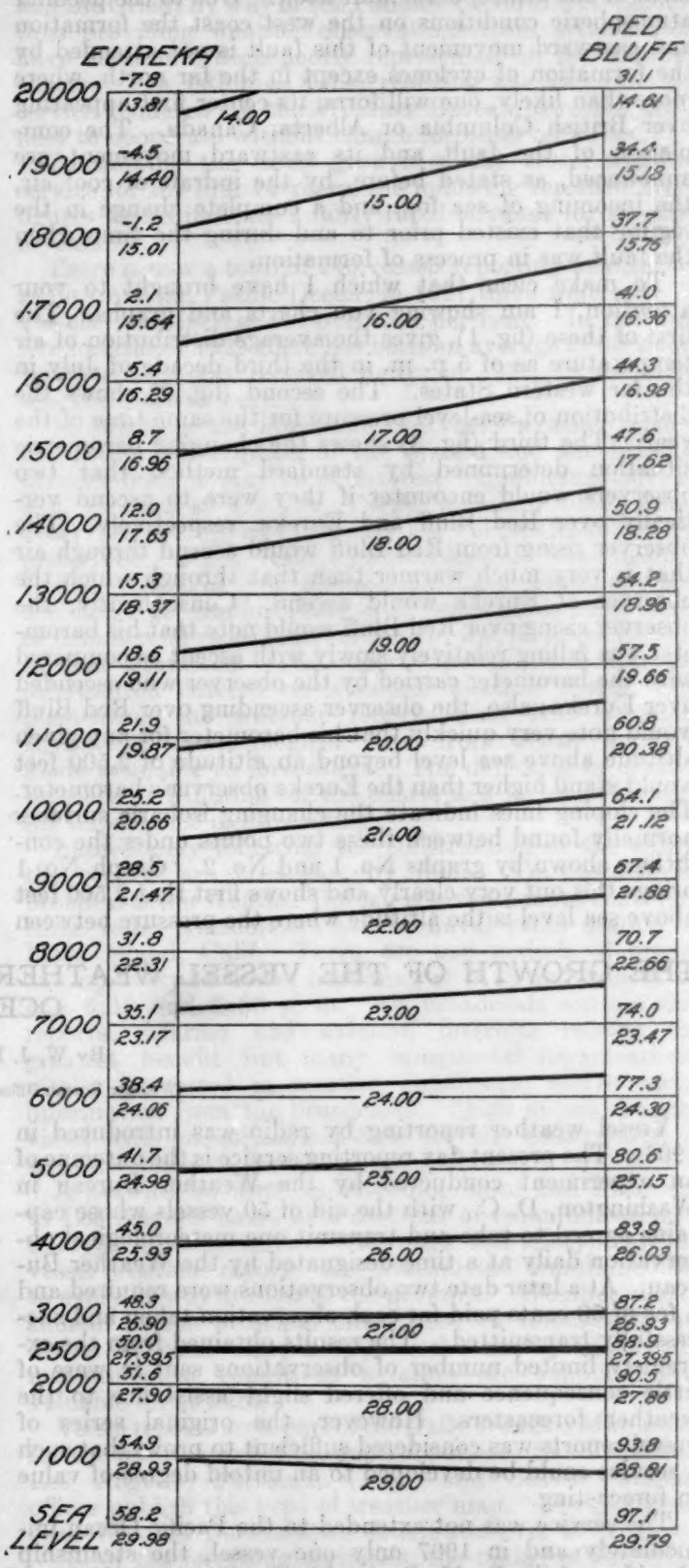


FIGURE 3.—Changes in pressure with elevation above Red Bluff and Eureka, Calif. respectively, due to surface temperature at the two places

involved in the rapidly rising temperature and falling barometric pressure, the meteorologist realizes that the fault has been accomplished the full length of the coast

under consideration and that very quickly thereafter there will be a marked indraft of cool air from the waters off the coast, a corresponding fall in temperature over the interior, and the beginning of the eastward movement of the atmospheric fault itself. Due to the peculiar atmospheric conditions on the west coast the formation and eastward movement of this fault is not attended by the formation of cyclones except in the far north, where more than likely, one will form, its center first appearing over British Columbia or Alberta, Canada. The completion of the fault and its eastward movement are announced, as stated before, by the indraft of cool air, the incoming of sea fog, and a complete change in the régime that existed prior to and during the time when the fault was in process of formation.

To make clear that which I have brought to your attention, I am showing you charts and graphs. The first of these (fig. 1), gives the average distribution of air temperature as of 5 p. m. in the third decade of July in the far western States. The second (fig. 2) shows the distribution of sea-level pressure for the same time of the year. The third (fig. 3) shows the changing barometric situation determined by standard method that two observers would encounter if they were to ascend vertically over Red Bluff and Eureka, respectively. The observer rising from Red Bluff would ascend through air that is very much warmer than that through which the observer at Eureka would ascend. Consequently, the observer rising over Red Bluff would note that his barometer was falling relatively slowly with ascent as compared with the barometer carried by the observer who ascended over Eureka; also, the observer ascending over Red Bluff would note very quickly that his barometer for any given altitude above sea level beyond an altitude of 2,500 feet would stand higher than the Eureka observer's barometer. The sloping lines indicate the changing isobaric surfaces normally found between these two points under the conditions shown by graphs No. 1 and No. 2. Graph No. 1 brings this out very clearly and shows first that 2,500 feet above sea level is the altitude where the pressure between the coast and the interior as represented by Eureka and Red Bluff is the same, and secondly, that above that level the barometer over the interior stands higher in comparison with that over the ocean, despite the fact that at sea level the pressure at Eureka was the higher of the two. Consequently, we see that an entirely different régime of winds and pressure gradients is called for above this altitude, 2,500 feet, in comparison with the stratum below it.

Those of you who attended the meeting of the American Meteorological Society in Claremont in 1928 will recall that the question of a changed régime of pressure gradients and winds at high altitudes in comparison with lower altitudes was the subject of considerable discussion. It was then brought out that above the surface system of pressure distribution—namely, high barometric pressure over the coast and low barometric pressure in the interior—there was a complete reversal to high barometric pressure over the interior and low barometric pressure over the ocean. The charts of free-air winds at 4,000 meters of July 8, 9, and 10, 1928, show very clearly the transformation of the sea-level low-pressure system of the interior into a high-pressure system at 4,000 meters altitude. At this level the upper air winds show very definitely that the winds are anticyclonic. Here we have an example of the true Ferrel thermal cyclone.

The accurate forecasting of the changes in wind, weather, and temperature resulting from the formation and degradation of the west coast atmospheric fault calls for great skill on the part of the meteorologist. I am free to admit that I can not always determine from the available data exactly when the fault will begin and when it will be brought to an end. The forecasting of the changes associated with it is essentially different from the forecasting of changes commonly associated with the comings and goings of cyclones and anticyclones. We have made progress in that we know very definitely that we have an atmospheric fault that in our summer months is constantly forming or dissipating, and we shall soon learn its peculiarities and propensities and be able to forecast them.

THE GROWTH OF THE VESSEL WEATHER SERVICE OF THE NORTHEAST PACIFIC OCEAN[1]

By W. J. HUTCHISON

[Weather Bureau Office, San Francisco, Calif.]

Vessel weather reporting by radio was introduced in 1906. The present day reporting service is the outcome of an experiment conducted by the Weather Bureau in Washington, D. C., with the aid of 50 vessels whose captains agreed to take and transmit one meteorological observation daily at a time designated by the Weather Bureau. At a later date two observations were required and a fee of 50 cents paid for each observation taken and successfully transmitted. The results obtained from the extremely limited number of observations sent in were of little consequence and offered slight assistance to the weather forecasters. However, the original series of vessel reports was considered sufficient to prove that such a service could be developed to an untold degree of value in forecasting.

The service was not extended to the Pacific Ocean immediately and in 1907 only one vessel, the steamship *President* of the Pacific Steamship Co., was authorized to make reports. It is understood this vessel was the only one operating on the Pacific which carried wireless equipment at that early date. Lack of wireless apparatus on ships was one of the principal causes for the slow advance of vessel weather service on the Pacific.

Following the introductory years, the pioneers of this department of the weather work encountered many obstacles. Chiefly among them was the shortage of funds appropriated for observers' fees and radio tolls charged for transmission from ship to shore. Other stagnating influences contributing to the sluggish advance of the vessel service on the Pacific may be summarized as follows:

1. Difficulty in obtaining increased appropriations.
2. Inadequate increases were exhausted with but few new vessel stations established.
3. As mentioned previously, lack of wireless equipment on ships.
4. Seeming slowness of shipping companies to realize the need for wireless or radio equipment.
5. Unreliable radio apparatus with transmission service suffering accordingly and delivery of weather messages uncertain.

It may be readily seen from the foregoing that the struggle to build up the Pacific vessel weather service to a point of real usefulness was a difficult task. Progress was very limited for the first 14 years.

[1] Presented before the meeting of the American Meteorological Society at Berkeley, Calif., June, 1929.

In 1919, authority was granted for the appointment of 12 vessel weather stations. The number of reports received from these ships were insufficient to be of real value but they may be regarded as the entering wedge in the development of the service. Forecasters made only limited use of the observations furnished owing to the desultory nature of the reporting and the vast areas of the ocean unheard from. Systematic plotting of oceanic pressure areas, which is the basis for accurate forecasts and timely warnings in present day forecasting on the Pacific coast, was not possible at this time.

Following the period of uncertainty, a slow but gradual growth began and for two years marked improvement was noted. By the year 1921, the service had reached such a magnitude of importance as to demand recognition from Government officials outside the Weather Bureau, and in January, 1921, all Shipping Board vessels were issued general instructions to cooperate to the fullest extent. The addition of this large fleet to the service reflected gratifying improvement. During this period of progress efforts were made to enlist the aid of Japanese vessels operating between our coast and Japan and north of latitude 45°. The serious need for reports from the routes followed by the Japanese made it imperative that we gain their cooperation. These early attempts to secure their assistance were of little avail. Vessel weather stations were established aboard two ships, but after a short time it became apparent that the desired results could not be obtained and the stations were abandoned.

In 1925, Maj. E. H. Bowie proposed that Japanese cooperation be secured through diplomatic channels. Accordingly, the Chief of the Weather Bureau at Washington, D. C., communicated the proposal through these channels to the Japanese Government. Negotiations were successful and the Japanese instructed their ships operating north of 45° to report. An interesting point noted in the agreement is the absence of charges for observer's fees. Ship tolls only are paid to the Japanese Government, through diplomatic channels.

In the year following, similar action was taken to secure the assistance of Japanese ships operating south of latitude 45°. Favorable response was made to the new proposal with the result that all Japanese vessels were instructed by their Government to send radio weather reports when north of latitude 10° and between our coast and the one hundred and eightieth meridian. To-day several of the Japanese vessels are considered among the most reliable and consistent reporters.

Prior to 1928, vessel weather reporting was confined to transoceanic ships and coastwise reports were considered unnecessary. However, increasing demands for more extensive forecasting and warning services called for a study of the situation to determine what additional aid could be procured. After careful deliberation the forecasters at San Francisco amended the rule that had prevented coastwise ships making radio reports. Authorization was requested from the Chief of the Weather Bureau to establish a group of 12 coastwise vessel weather stations. These vessels cover coast points from San Diego, Calif., to Kodiak, Alaska. Reports from Alaskan waters are of the greatest importance to forecasting for the western district. Authority was granted and on July 1, 1929, coastwise vessel weather reporting will be inaugurated.

Early in 1929, the Honolulu Weather Bureau expressed a desire for additional ship reports from adjacent waters. With the assistance of Representative Houston, of Honolulu, the Isthmian Steamship Line was induced to allow its fleet of 28 vessels to join the ranks of radio vessel weather reporters. This company's ships make more or less regular voyages between the Atlantic coast and the Orient by way of the Panama Canal and Honolulu, thus providing weather observations from areas which have heretofore been poorly represented on the weather charts. The Isthmian Line, realizing the value of the service rendered by the Weather Bureau, directed their fleet to cooperate without charge for observer's fees.

Considering the tardy growth of the vessel weather service for the first 14 years, the following representative figures would indicate a fairly rapid advance for the past 8 years.

There is now a total of 240 vessels reporting weather by radio from the Pacific Ocean; in 1921 there were only 70 vessels. An increase of over 200 per cent. In the first five months of 1929 there has been an average of 50 vessel weather messages received daily; in 1921, 18 messages was the daily average.

To illustrate the importance of vessel weather reporting a short description of the system and the benefits derived from it may be of interest. Simultaneously, at 4 a. m. and at 4 p. m., Pacific standard time, vessel observers on ships en route over the Pacific Ocean, within prescribed limits, take meteorological observations. Coded messages containing the data obtained and the ship's geographic position are radioed through naval or commercial radio land stations to the Weather Bureau at San Francisco. The reports are decoded and the information entered on synoptic weather charts, supplementing the weather reports from land stations. Invaluable meteorological data from ocean areas is made available to forecasters. The depicting of oceanic pressure distribution on the charts is a factor of exceeding importance in forecasting.

Immediately following the construction of the charts the reports are broadcast by radio. To execute the broadcasts the Weather Bureau is given remote control of three radio transmitters at the naval radio station at Mare Island, Calif. There are two periods of broadcasting every 12 hours, beginning at 6:18 and 7:30 a. m. and 6:18 and 7:30 p. m. All broadcasts contain ship reports. Marine and aviation interests receive the greatest benefit but many commercial organizations, vitally interested in weather conditions, derive useful information from the broadcasts. Ships at sea are provided with meteorological data for the construction of weather charts to be used in navigation.

A network of airports extending from San Francisco to Los Angeles have, as a medium of communication, a teletype printing service. Through this teletype system vessel weather reports are transmitted simultaneously to every airway station in the network. Weather charts, similar to the principal chart used in forecasting, are drawn at each airport. From the survey of oceanic meteorological conditions aviators are supplied with valuable flight data.

Vessel reports are a part of the Daily Weather Map issued for the information of the general public. San Foancisco, Los Angeles; Portland, Oreg.; and Seattle weather offices publish this type of weather map. The San Francisco Weather Bureau alone distributes over 800 copies.

All of the foregoing activities, the taking of the vessel observations, the centralization of the radio reports, the distribution of them and the data derived from them and the preparation of the printed weather map for

mailing, require a total of slightly over four and one-half hours time.

Due to the successful and extensive development of the vessel weather service comprehensive studies are made of meteorological conditions over the Pacific Ocean. The knowledge of oceanic pressure distribution, the most vital factor in forecasting for the far Western States, becomes available to forecasters. The isobaric reproduction on the synoptic charts of pressure systems as indicated by vessel reports pictures the movements of cyclonic and anticyclonic areas. The continuous eastward march of "HIGHS" and "LOWS" may be closely followed. The constant changing conditions; the rapidity of movement; the relative positions of cyclonic and anticyclonic areas; the intensity of a depression; the steepness of intervening gradients and all the information derived from these factors form the basis for accurate conclusions in forecasting. Without vessel-weather observations forecasters would be confronted with a very puzzling situation.

The value of the forecasting and warnings can not be estimated. Every industry, enterprise, organization, or the individual, whose welfare is affected by weather conditions receives invaluable benefits from this service. Ever increasing demands for a more extensive weather service are taxing the Weather Bureau to capacity. Fairly rapid strides have been made in recent years in the extension of the services of the Weather Bureau and vessel weather reporting has played an important part in the advance.

METEOROLOGICAL NEEDS OF A CLASS A 1 A AIRPORT[1]

By D. M. LITTLE

The Secretary of Commerce is empowered by law to rate airports as to their suitability upon application of the owner. After conforming to certain basic requirements, airports may be given ratings indicated by a letter, a figure, and another letter, the first letter indicating the general facilities and equipment at the airport, the figure indicating the available landing area, and the last letter indicating the night flying equipment. Thus the rating A 1 A is the highest rating given airports.

Under general facilities and equipment, an airport, in order to obtain a rating of "A" or "B," must have meteorological instruments including an anemometer, barometer, and a thermometer, in addition to a bulletin board and facilities for giving pilots the most recent weather information. Ratings of "C" or "D" do not require meteorological facilities. Under night-flying equipment an airport must have a ceiling projector, an alidade for measuring the height of ceiling, and sufficient personnel for giving weather service at all times in order to receive a rating of "A." A rating of "B" will be given when an airport is without a ceiling projector, and ratings of "C" or "D" may be given when the airport is without night meteorological facilities or personnel.

The meteorological needs of a class A 1 A airport is much greater than the bare requirements for the rating. In this paper the needs are classified under three headings—Personnel and service, Communication facilities, and Meteorological instruments and facilities.

PERSONNEL AND SERVICE

1. *Government service at airports.*—At airports designated as control stations on established commercial airways in use more or less 24 hours per day there are ordinarily not less than four Weather Bureau officials on the meteorological staff—i. e., two meteorologists and two observers. At similar stations on established commercial airways where from 15 to 20 hours' service per day is sufficient for the present flying one meteorologist and two observers are usually assigned. At all other airport stations and aerological stations 12-hour service is maintained by the assignment of one meteorologist and one observer. Employees below the rank of junior observer should not be assigned to airport stations, as the responsibility is too great to be placed with men of lesser capacity. Service at Weather Bureau airport stations is progressing at a fast pace. Experience has shown that close contact between the meteorologist and the pilot is absolutely necessary, and this mutual exchange of meteorological information and flying problems is conducive to safe and economical air transportation.

2. *Municipal service at airports.*—Many large and important municipal airports over the country, located on and adjacent to established airways, will not be needed as Weather Bureau airway control stations, and therefore will be without Government meteorologists. However, Government airway weather and communication service is available at small cost to such airports, but it is necessary for the municipalities to employ their own meteorologists. This has already been done in several instances, and the airports are rendering as efficient service as at the Weather Bureau airport stations.

3. *Service at privately owned airports.*—The need for meteorological service at a privately owned airport where air-transport operations are carried on is just as great as at a municipal airport. Here, again, it will be necessary for the airports or air-transport companies to employ their own meteorologists. In some cases it will be necessary for an air-transport company to employ one or more meteorologists, placing them at strategic points along their particular flying route when such route does not follow the established commercial airway. One company has already set aside $100,000 for its own complete meteorological service along such a route.

Private and municipal airport meteorologists, of course, should be experienced and thoroughly familiar with the aerological, marine, and weather codes of the United States Weather Bureau. With the wealth of information available, as explained later under "Communications," the meteorologist can prepare synoptic maps of 12-hour weather conditions, tabulate and map hourly airway weather reports supplemented with 3-hour summarizations and short-range forecasts based on off airway reports, prepare multilevel maps of upper air winds, and furnish all pilots with current weather reports in tabular form. In addition he would advise the pilot of the best weather route, how high to fly in order to take advantage of "tail winds," and the weather changes to be expected during a flight along an off airway route. In short, he would render for the municipal and privately owned airport all of the service available at a Government station and devote a portion of his time to research on meteorological problems particularly affecting his area.

[1] Presented before the Berkeley meeting of the American Meteorological Society in June, 1929.

COMMUNICATION FACILITIES

At airports where Weather Bureau airport stations are established the Government provides all necessary communication facilities, such as long-distance telephone, telegraph, teletype circuits, and radio stations. Municipal and private airports without such a station can easily avail themselves of all meteorological information. An airport located near a Government airway station where long-line teletype facilities are available can arrange for a drop on the circuit whereby the airport pays for its own drop. Also the installation of an inexpensive short and long wave radio receiving set is essential. Reports transmitted by the Weather Bureau to the Department of Commerce radio station are transmitted on the long-line teletype as well as broadcast by voice. For the preparation of 12-hour synoptic maps and multilevel upper air maps, it will be necessary for the airports to arrange to have an operator copy the Weather Bureau broadcast from the naval radio. An airport complying with the A 1 A requirements needs this tie in with the Government communication system before it can hope to give its pilots the best service obtainable.

METEOROLOGICAL INSTRUMENTS AND FACILITIES

For the larger important airports an ideal instrumental layout is as follows: Pressure tube anemograph, mercurial barometer, high-grade aneroid barometer, barograph, hygrothermograph, psychrometer, maximum minimum and exposed thermometers, rain gage, sunshine recorder, pilot-balloon equipment, ceiling projector with alidade, and an airplane meteorograph. In this list the pressure-tube anemograph was selected in preference to the wind vane, anemometer, and recorder because a record of wind fluctuations and gustiness is needed at important airports. A mercurial barometer is needed for accurate measurements of barometric pressure. A record of temperature and humidity as obtained with a hygrothermograph and psychrometer is important. All airports have more or less fog to contend with during certain periods of the year, and a continuous record of relative humidity and temperature will be useful in research work on this problem. In addition, the dew point of the air is required when giving airway weather reports. A sunshine recorder is of value for records of beginnings and endings of cloudiness or fog at the airport. Pilot-balloon equipment is recommended for airports employing meteorologists, especially where the airport is far removed from a Weather Bureau aerological station. Even if located close to a Weather Bureau aerological station, frequently an observation can not be obtained at the Weather Bureau station because of local low clouds or fog, while an airport meteorological station several miles away could make the observation in a clear sky or vice versa. In one case this is carried on successfully through the Government station advising the municipal station at times when low clouds interfere with the observation at the Government station. The ceiling projector and alidade for measuring the ceiling or altitude of the clouds at night is required for a class A rating. Height of ceiling, a difficult observation at best, is made extremely simple with this equipment. All airports should have this equipment, regardless of whether or not a meteorological station is planned. An airplane meteorograph has been included with the list of meteorological instruments for airports employing meteorologists for the reason that upper air records are badly needed. The airport meteorologist would have little difficulty in securing the pilot's cooperation in this work.

Substitutions and omissions in the above list of instruments may be made, of course, to meet the requirements and budget of each individual airport. The rule to follow in selecting meteorological instruments is to begin with the basic requirements of an "A" rating and substitute or supplement with self-recording instruments as far as possible.

Under "Facilities" an airport should provide space and office equipment for a meteorological office in the administration building. The office should contain a bulletin board showing current upper-air wind data from surrounding aerological stations, United States Weather Bureau airway forecasts, current airway weather reports, and a daily weather map. Wall maps, topographic maps, and airway strip maps are desirable in the meteorological office.

It is interesting to note that one after another of the problems affecting commercial aviation have been overcome; motors have been developed to the point where with proper care seldom is there a complete failure; instruments have been developed and improved; pilots are becoming more and more experienced; planes have been improved for speed and safety; and now one of the vital problems affecting commercial aviation—i. e., the weather problem—is being investigated and minimized by the installation of meteorological instruments, by fast communication service, by the tie in of airports with the Government airway meteorological and communication system, and by the employment of meteorologists at airports.

WHAT A TORNADO LOOKS LIKE

By S. D. FLORA

A well-developed tornado is the most amazing and terrifying atmospheric phenomenon ever seen in inland America. The first sight of one at a distance—and a hundred or more occur each year in the country—gives the impression of a contradiction of nature's laws that permits such a storm to form at all. As it approaches with its peculiar whistling sound that rapidly changes to a terrific roar and buildings are blown to pieces as though they were made of cards, the effect is enough to strike terror in the stoutest of hearts.

Contrary to the popular idea, a tornado seldom gives the impression of a huge inverted funnel. It has been more commonly described by eyewitnesses as a gigantic elephant trunk writhing about or a long rope dangling from the sky that spreads destruction where ever it touches the ground.

One of the most spectacular tornadoes on record struck the edge of Hardtner, Kans., about 5:15 p. m. of June 2, 1929. The sky was only partly overcast at the time and the sun shone full on the pendant cloud, making it a striking sight for 30 miles across the almost level country adjoining. Instead of moving at express-train speed, as tornadoes generally do, this one seemed to loiter and remain almost stationary for the greater part of half an hour.

In describing it an eye witness said, "If you can imagine a big, gray elephant trunk or sausage balloon strung across the town with the upper end in the clouds

and the lower switching about in a cloud of dust on the ground, you can imagine something of what the twister looked like when it passed Hardtner."

When the tornado disappeared, ambulances were rushed to Hardtner from as far as Alva, Okla., almost 20 miles distant, under the supposition that the town had been wiped out and hundreds of persons mangled or killed. Fortunately only the edge of the town had been struck and no one was injured. People had seen the tornado approaching and had taken to storm caves—the well known "cyclone cellars" of the West—and basements, where they were safe. After the disturbance was over it was reported, "People came out of the ground like ants."

As in the case of many tornadoes, this one was accompanied by a heavy fall of hail. At Kiowa, 10 miles to the east, where the sun could still be seen shining over the top of the tornado cloud, slugs of ice, disk shaped, and 2½ inches wide and almost an inch thick, fell in the sunlight like gleaming meteors out of a black cloud that backed in from the east. Finally, the parent cloud of the tornado merged with the black hail cloud and the whole mass moved off toward the northeast.

PENSACOLA WATERSPOUT OF JUNE 14, 1929

By Lieut. P. G. HALE, U. S. Navy

A waterspout occurred in Pensacola Bay from 9:31 to 9:37 on the morning of the 14th of June, 1929. A somewhat detailed report of the occurrence is made, for it is believed that some new data will be made available for the study of waterspouts. The waterspout was not a large one and lasted only six minutes, but it is the attendant data which excuses the length of the report.

To begin with, an aerograph (airplane meteorograph) flight was made that morning up to 3,000 meters. The writer of this article was the observer. The following are the notes taken during the flight:

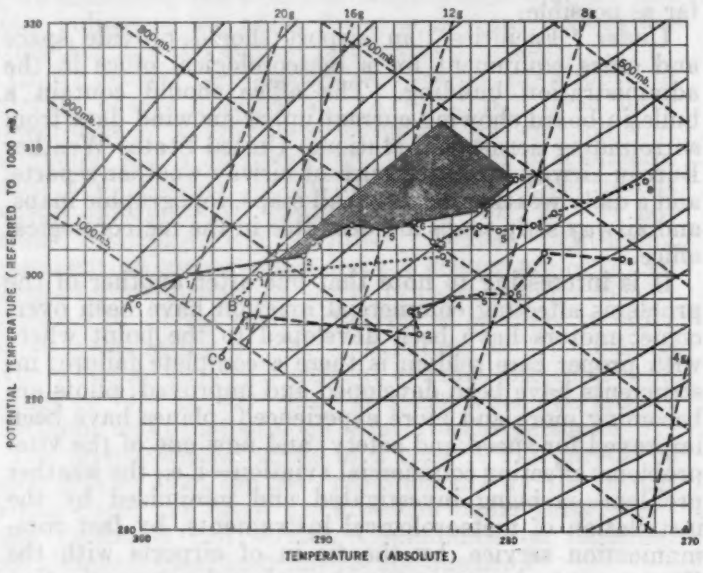


FIGURE 3.—Enlarged portion of tephigram of Figure 2. (See text.)

Takeoff at 0624. Light haze. Tall cumulus over the Gulf of Mexico. Few strato-cumulus around the horizon. Base of the cumulus about 450 meters. Haze ring to the east at an altitude of about 2,800 meters, cumulus thrust through it in places. Tops of the cumulus over the Gulf of Mexico were well over 3,000 meters. Quite bumpy throughout the flight. Top of the flight at 0646.

After landing the data were worked up, using an adiabatic chart and a tephigram chart to plot them. The instrument used on the flight was a Friez aerograph, type Aero-1928-USN, No. 51. Frequent calibrations insure that the instrument is reasonably correct. A copy of the work sheet used in picking off the data from the aerograph chart accompanies this report.

On the adiabatic chart (fig. 2) there are plotted (1) a temperature-pressure curve; (2) a curve to determine graphically the altitude of the significant points; (3) a humidity-pressure curve; (4) a wind velocity curve, from pilot balloon ascent at 0600; (5) wind velocity-altitude curve, from pilot balloon ascent immediately following the waterspout, about 10 a. m.; and (6) a vapor pressure-pressure curve. These various curves are labeled on the adiabatic chart. The 6 a. m. pilot balloon ascent reached an altitude of only 1,530 meters, when the balloon was lost due to haziness. The ascent immediately following the waterspout was made to an altitude of 5,300 meters, where the balloon disappeared behind a cumulus cloud.

The aerograph sounding is plotted on a tephigram chart (fig. 3) the scale of which is rather small, so an enlarged portion of the tephigram chart is magnified and the sounding replotted on it to better show the details. Both the tephigram chart and the magnified portion on a separate page are submitted with this report (fig. 3).

The upper left curve "A" is the tephigram or temperature-potential temperature curve on the tercentesimal scale. The lower right hand curve "C" is the dew-point temperature plotted against the pressure. The central curve "B" is a curve connecting the points at which air rising adiabatically from points on the tephigram, curve "A," would become saturated and begin to form cloud.

For a description and better understanding of the curves plotted see "Physics of the Air," by W. J. Humphreys, second edition, 1929, pages 259–261.

The shaded area represents the energy-per-unit mass of saturated air available for convection from lower to higher levels. The upper right edge is cut off at the end of the tephigram, as no information is available above point "8" and no assumptions are made. It might be noted that the entire area as shaded really is representative of the energy available at point "1." An area almost as large would represent the energy available at the surface or point "0." At point "2" there is no energy available and but a slight amount at point "3." Another feature of the tephigram, curve "A," is that except between points "2" and "3" and points "7" and "8" the curve is more nearly horizontal than the psuedo-adiabats, and thus air from the surface up to point "7" once saturated becomes unstable except for the shallow layer between "2" and "3."

Tephigrams are drawn daily as part of the routine at the United States naval air station, Pensacola, Fla., and they are completed prior to the completion of the weather map. So far, their principal use has been in the prediction of thunderstorms for the current day. This is based on a study of the size of the energy area and the levels at which energy is available. In general when curves "A" and "B" are widely separated and the energy does not exist thunderstorms do not occur. When the two curves are close together and the energy area is evident but not large, thunderstorms may or may not occur. When

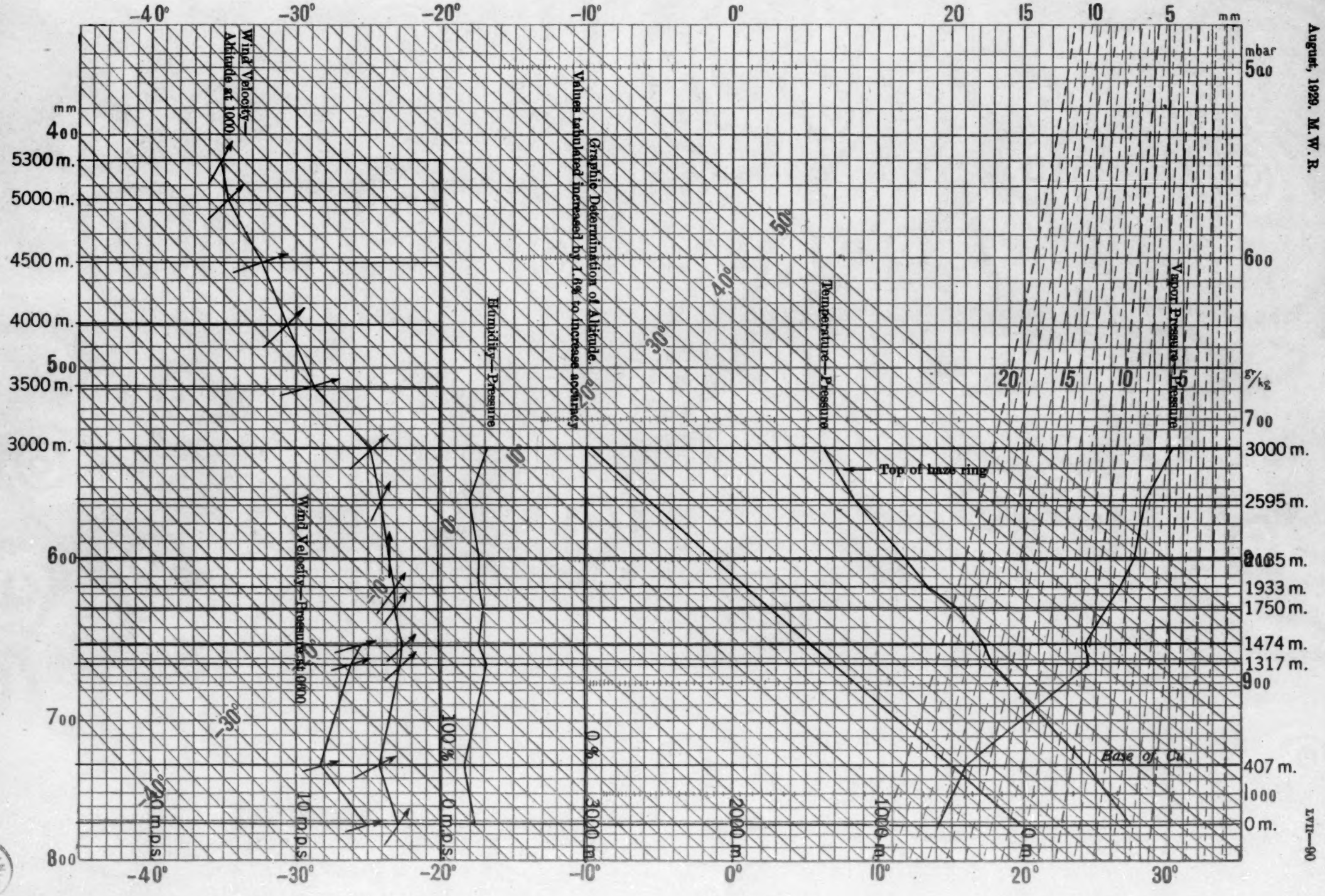
(To face p. 338)

FIGURE 1.—Waterspout in Pensacola Bay, June 14, 1929, taken from an O-2V landplane. (Published by permission of the Chief, Bureau of Aeronautics, Navy Department)

UNIV. OF FLA.

P. G. H. **Fig. 2. Adiabatic Chart**

To face p. 338



| | | |

there is a large energy area, as on the accompanying tephigram chart, thunderstorms almost invariably follow during the day.

At 8 a. m. on June 14, when observations were being made for the aerological record, it was noted that there were seven-tenths cumulus clouds with a prevailing direction from the south. It was noted, however, that some cumulus moved from the west and some from the southwest. These observations were made with a Weather Bureau type nephoscope. By 9:30 the development of the cumulus had continued until forms of cumulo-nimbus were appearing. There was a partially developed cumulo-nimbus to the south over the Gulf from which rain was falling. There was another to the west, about 5 miles off, from which rain was falling, and to the north, about 10 miles distant, was a third from which rain was falling. This was the setting as observed by the writer, who was on top of the observatory to watch the developing squalls in order to warn the squadrons of possible dangerous weather for flying.

By chance, attention was directed toward the north, where at 9:31 the waterspout formed. It formed about 2 miles to the north of the station and about a half mile offshore. It lasted six minutes—until 9:37. During that time it moved very slowly in a general southeast direction. This was determined by observations from the observatory and from planes in the vicinity.

The waterspout was observed from the aerological observatory to form in the clouds and descend to the water. The descent did not take more than 20 seconds. The descending column laid over flat under the cloud and then descended rapidly in an arched shape. As viewed from the south the column had a shape similar to that shown in the picture, except that the slope was to the right or east. In the picture the slope is toward the left or south, so that actually the column sloped toward the southeast, which was its general direction of movement.

When the waterspout first appeared, a landplane was ready to take off from the station field with a photographer. Its regular mission was delayed and the plane flew near the waterspout, where two exposures of it were made. Only the picture accompanying this report turned out well. From the pilot who flew the plane, Lieut. (Junior Grade) H. S. Duckworth, U. S. Navy, and the photographer who accompanied him, G. A. Carroll, private first class, U. S. Navy, the data of the next paragraph were obtained.

The altitude of the base of the cloud from which the waterspout descended was 1,100 feet by the plane's altimeter. The picture was taken looking toward the west when the plane's altitude was 500 feet. The base of the waterspout was estimated to be one-half to three-quarters of a mile off shore. The plane was approximately 1,500 feet from the waterspout when the picture was taken. The waterspout was between 20 and 30 feet in diameter. At the base, faintly discernible in the picture, was an outer whirl of cloud or spray concentric with the waterspout, about three times its diameter and extending upward 50 feet from the surface of the water.

In the background of the picture is what appears to be another waterspout forming. This was not observed by anyone and is thought to be rain falling or a defect in the negative.

Many people who were close to the waterspout, including those who were in the photographic plane, were questioned regarding the direction of rotation. This important evidence was not obtainable, as no one seems to have noted it. Neither was thunder or lightning observed in connection with the waterspout.

The waterspout disappeared more rapidly than it formed. It was seen to break near the surface of the water and rapidly draw up into the cloud above.

This report is prepared because it is thought that this is the first time data of the character presented here has been available in connection with the study of waterspouts. No conclusions will be attempted other than to suggest that the predominating feature in the formation of this waterspout was vertical convection. The pilot balloon ascent taken immediately after the formation of the waterspout shows a general southwest wind which varied from south to west-southwest. While the noted movements at 8 a. m. of cumulus clouds from the south, southwest, and west indicate a difference of direction of the upper air perhaps sufficient to initiate a whirl, the tephigram certainly shows a large supply of energy to produce an accelerated vertical convection.

TABLE 1.—*Work sheet used in transcribing the data from the airplane meteorograph record sheet, June 14, 1929, at Pensacola, Fla.*

Significant points	Wind		Temperature (correct base line 26.5° C.)					Potential temperature (reference to 750 mm.)		Pressure (correct base line 765 mm.)					Humidity (correct base line 77 per cent)				Vapor pressure	Dew point		Computed altitude (meters)
	Direction to 16 points	Velocity (m. p. s.)	Ordinate difference	Factor	Corrected ordinate difference	Correct temperature °C. (base line+corrected ordinate difference)	°C. absolute (corrected °C.+273)	°C.	°C. absolute (°C.+273)	Ordinate difference	Factor	Temperature correction	Corrected ordinate difference	Correct pressure (mm.) (base line+corrected ordinate difference)	Ordinate difference	Factor	Corrected ordinate difference	Correct humidity, per cent (base line+corrected ordinate difference)	Table 78, Smithsonian	Tables 72 or 78, Smithsonian °C.	Tables 72 or 78, Smithsonian °C.—Absolute (°C.+273)	
0	WSW.	4.9	+1.0	1	+1.0	27.5	300.5	25.0	298.0	+6.0	0.94	0	6	771	−2.0	0.8	−2.0	75	20.65	22.6	295.6	0
1	WSW.	8.0	−2.0	1	−2.0	24.5	297.5	27.0	300.0	−38	.94	0	36	729	+6.0	.8	+5.0	82	18.92	21.2	294.2	407
2	WSW.	6.1	−8.5	1	8.5	18.0	291.0	28.5	301.5	110	.94	0	103	662	−13.0	.8	−10.0	67	10.38	11.8	284.8	1,317
3	WSW.	5.3	−9.0	1	9.0	17.5	290.5	29.5	302.5	122	.94	0	115	650	−8.0	.8	−6.0	71	10.65	12.2	285.2	1,474
4	----------	----------	−11.0	1	11.0	15.5	288.5	31.0	304.0	147	.94	0	138	627	−10.0	.8	−8.0	69	9.13	9.9	282.9	1,750
5	----------	----------	−13.0	1	13.0	13.5	286.5	30.5	303.5	160	.94	0	150	615	−7.0	.8	−6.0	71	8.25	8.4	281.4	1,933
6	----------	----------	−14.5	1	14.5	12.0	285.0	31.0	304.0	177	.94	0	166	599	−7.0	.8	−6.0	71	7.48	6.9	279.9	2,135
7	----------	----------	−18.0	1	18.0	8.5	281.5	32.0	305.0	212	.94	0	199	566	+3.0	.8	+2.0	79	6.57	5.1	278.1	2,595
8	----------	----------	−20.0	1	20.0	6.5	279.5	34.5	307.5	240	.94	0	226	539	−13.0	.8	−10.0	67	4.87	0.8	273.8	3,000

NOTES, ABSTRACTS, AND REVIEWS

G. C. Simpson on the distribution of terrestrial radiation (1)—*Radiation balance.*—According to the author, "The difference between the intensity of the terrestrial radiation (R) and of the effective solar radiation (S) represents the rate of accumulation or loss of heat due to radiation. This is a very important meteorological factor, for on it depends nearly every process which takes place in the atmosphere."

The outgoing terrestrial radiation (R).—Again the author states, "It will be sufficient to recall (2) that the outgoing radiation depends on four factors only, namely, (a) the surface temperature, (b) the temperature of the upper surface of the clouds, (c) the temperature of the stratosphere, and (d) the amount of cloud. Given the values of these four factors, the intensity of outgoing radiation is first calculated for clear skies, R_1; then for overcast skies, R_2; then the actual intensity of the outgoing radiation is given by

$$R = R_1 (1 - C) + R_2 C,$$

in which C is the cloud amount expressed as a fraction of the sky covered by clouds."

For surface temperatures, and for cloud amounts, values for the months of January and July determined by Dr. C. E. P. Brooks for 10° squares between latitude 70° N. and 70° S. were employed. They are plotted in Figures 2 to 5 of the paper.

The temperature of the upper surface of the clouds was taken to be 269° A. in all parts of the world (2), and the temperature of the stratosphere was taken to be a simple function of the latitude as follows:

Latitude	0°–10°	10°–20°	20°–30°	30°–40°	40°–50°	50°–60°	60°–70°
Stratosphere temperature	204	207	211	214	217	219	220

The resulting values of R are charted on maps, Figures 6 and 7 of the paper. The author calls attention to the remarkable uniformity of the value of R on both maps. For both seasons and for practically the whole area represented the values fall between 0.26 and 0.30 cal. per min. per square centimeter. On both maps there are, however, relatively high values on each side of the Equator, while at the Equator the values differ but little from those in polar regions. This is accounted for by the low temperature of the stratosphere and the large amount of cloud in equatorial regions. Desert regions are the source of the most intense outgoing radiation.

The effective solar radiation (S).—This is the quantity of solar radiation absorbed by the earth and its atmosphere, and is computed from the equation.

$$S = S' (1 - a)$$

where S' is the intensity of the incoming solar radiation and a is the albedo of the earth and its atmosphere. For values of a the author had adopted the following, which are the means of those given by Aldrich (3) and Ångström (4).

Cloud amount	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Albedo, a	0.17	0.22	0.27	0.32	0.37	0.43	0.48	0.54	0.61	0.67	0.74

Using for January and July values of a corresponding to the cloudiness for the different 10° squares, a value of the solar constant of 1.952, and relative values of radiation intensity for different latitudes at the limit of the atmosphere given by Angot (5), values of S were obtained. The differences, $S - R$ represent, as already stated in the first paragraph of this review, the rate of accumulation or loss of heat due to radiation, and are plotted in Figures 8 and 9 of the paper. In general, there is an accumulation of heat between latitudes 20° N. and 60° S. in January, and a loss between 20° and 70° N. In July there is an accumulation between latitudes 15° S. and nearly 70° N., with a loss between 15° and 70° S. There are, however, areas of maximum accumulation (in excess of 0.15 calories per minute per square centimeter) over South America, Africa, and Australia in January, and a belt of maximum accumulation of somewhat less intensity at latitude 30° N. in July. Also in July there are small areas of loss of radiation in the region of monsoon winds in India and in West Africa, due to the excessive cloudiness.

By a similar process, but using monthly mean values of temperature (6), (7), and cloudiness (8) for 10° zones of latitude instead of for 10° squares, and, further, taking into account the area of the different zones, the total effective solar (S) and terrestrial (R) radiation for each month have been computed for each zone and for the whole earth. The author calls attention to the symmetry of curves of net radiation ($S - R$) for the different seasons in the two hemispheres. There is, however, an excess for the whole earth in October to April, and a deficiency in May to September, on account of the varying distance of the earth from the sun.

For the whole year the outgoing terrestrial and the effective solar radiation should balance. The computed values of total terrestrial radiation exceed the computed values of the total effective solar radiation by 2 per cent, which is well within the percentage of accuracy of the values for the cloudiness and the albedo of the earth that were employed in the computations.

The author calls attention to the fact that "The whole of the summer hemisphere up to and beyond 60° is receiving more heat than it radiates." He therefore concludes that "There can be little flow of heat toward the north in July or toward the south in January. Similar conditions will be found to hold during the three months centering at the solstices, i. e., November to January and May to July."

The reviewer wishes to remark that if the different ways in which the effective radiation is expended are considered a latitudinal temperature difference in summer will be indicated. Thus, in high latitudes a considerable part of (S) is employed in melting the ice that has accumulated during the winter months, and is not available for raising the temperature of the earth's surface and of the air in the troposphere. Therefore, there are considerable differences in the temperature of the troposphere in high and in low latitudes during the summer months, although they are much less than in the winter months.

The new way in which radiation is treated in this paper will no doubt receive the careful consideration of meteorologists.

(1) Mem. R. Meteor. Soc. (London) 3, No. 23, 1929.
(2) Mem. R. Meteor. Soc. (London) 3, No. 21, 1928.
(3) Smithsonian Institution (Washington).
Ann. Astroph. Obs., 2:162, 1908.
Ann. Astroph. Obs., 4:379, 1922.
(4) Ångström, A. Beitr. Geophysik (Leipzig) 16, H. 1, 1926.
(5) Ann. bur. cent. Météor. (Paris), 1883, partie 1, pp. B136–161.
(6) Hoffner, Peterman's Geogr. Mitt. 1906, p. 33.
(7) Shaw, Sir Napier. Manual of Meteorology, Vol. II, 1928.
(8) Brooks, C. E. P. Mem. R. Meteor. Soc. (London) 1, No. 10, p. 129, 1927.

—*H. H. Kimball.*

A study of ground water in the Pomperaug Basin, Conn., by Oscar Edward Meinzer and Norah Dowell Stearns.[1]—In this paper the authors have made a quantitative study of the intake and discharge of water on the basin of Pomperaug River, Conn. The drainage basin of that river is situated in the central part of the western highland of Connecticut. It is about 17 miles in length and 8 miles in maximum width and has an area of about 89 square miles and comprises nearly all of the towns of Bethlehem and Woodbury and a large part of the town of Southbury, and small parts of the towns of Roxbury, Washington, Morris, Watertown, and Middlebury.

The highest point in the basin 1,150 feet above sea level, is at the northern extremity, near the village of Morris; the lowest point, only 100 feet above sea level, is at the mouth of Pomperaug River. The basin consists chiefly of rather rugged uplands, but in the south-central part there are extensive valley areas.

Inasmuch as this is one of the few efforts that have been made in the humid east to determine, month by month what becomes of the precipitation that occurs over a basin, the summary and conclusions of the authors are reproduced in full.—*A. J. H.*

SUMMARY

The water in the drainage basin of Pomperaug River is nearly all derived from precipitation—that is, from the rain and snow which fell on the basin. It is nearly all disposed of as run-off or by evaporation—that is, it is either carried out of the basin by Pomperaug River or else is evaporated directly or through the agency of plants. In the three full years covered by this investigation, October, 1913, to September, 1916, according to the data that were obtained, the precipitation averaged 44.48 inches, the run-off 20.66 inches, and the evaporation 23.20 inches a year (plus or minus a slight unknown difference in stream and soil storage). Moreover, there was during the 3-year period a net increase in ground-water storage (that is, in the quantity of water stored in the zone of saturation) which amounted to 1.85 inches, or an average of 0.61 inch a year, as is shown by the higher position of the water table at the end than at the beginning of the period.

During the 3-year period the ground-water recharge, or quantity of water that percolated from the surface to the water table and entered the zone of saturation, averaged 15.58 inches a year. Of this amount, an average of 8.76 inches seeped into Pomperaug River and its tributaries and was carried out of the basin by the river, 6.21 inches evaporated either directly or through the agency of plants, and 0.61 inch remained in storage in the zone of saturation.

According to these results, in the 3-year period the total run-off amounted to about 46½ per cent and the total evaporation to about 52 per cent of the precipitation, about 1½ per cent of the precipitation being stored in the zone of saturation. The ground-water recharge amounted to about 35 per cent of the precipitation, of which somewhat more than half was disposed of as run-off and somewhat less than half by evaporation. More precisely, the ground-water run-off amounted to about 19½ per cent of the precipitation, the ground-water evaporation to about 14 per cent, and the net increase in ground-water storage to about 1½ per cent.

There was no marked seasonal distribution of the precipitation but a very pronounced seasonal distribution of the evaporation. Consequently, each year was divided into a replenishing and a depleting season. In the replenishing season, from late fall to early spring, an average of approximately 7 inches of water was stored in the zone of saturation, over and above the withdrawals as run-off and by evaporation; in the depleting season, from late spring to early fall, nearly a like average amount was withdrawn from storage, in addition to the contributions that were occasionally received by the zone of saturation during this season. Most of the water withdrawn from storage during the depleting season was utilized by the vegetation or otherwise evaporated; only a small part ran off through Pomperaug River. In any long period of years the average seasonal depletion will, of course, be very nearly equal to the average seasonal replenishment.

In the following tables are given a summary of the monthly and annual inventories of the water supply of this basin during the period covered by the investigation:

Inventory of the water supply of the Pomperaug Basin, July, 1913, to December, 1916, in depth in inches over the drainage area

	Precipitation	Increase or decrease of ground water in storage	Ground-water run-off	Ground-water recharge	Ground-water evaporation	Total run-off	Total evaporation plus increase or minus decrease in surface and soil storage	Principal changes in surface and soil storage or other conditions that make the figures given in last column greater or less than total evaporation
1913								
July	2.07							
August	3.35		0.13			0.25		
September	3.43		.17			.35		
October	9.21	+4.30	.52	5.67	[1] 0.85	2.57	2.34	Increase in stream and soil storage.
November	2.72	+1.38	1.73	3.11	[2]	2.73	−1.39	Decrease in soil storage.
December	2.58	−.23	1.42	1.19	[2]	2.24	.57	
1914								
January	3.01	−.77	1.00	.23	[2]	1.33	2.45	Estimate of total run-off probably too low.
February	3.10	−.31	[3].40	.09	[2]	.58	2.83	Increase in snow storage; estimate of total run-off probably too low.
March	6.01	+.23	.86	1.09	[2]	4.32	1.46	
April	4.20	+1.69	1.03	2.72	[2]	2.94	−.43	Decrease in snow storage.
May	3.06	−.08	.85	[4] 1.84	1.07	2.35	.79	Decrease in soil and stream storage.
June	3.11	−2.30	.39	[5]	1.91	.63	4.78	
July	5.68	−1.46	.38	[4].45	1.53	.70	6.44	
August	3.67	−.77	.29	[4].45	.93	.45	3.99	
September	.31	−1.23	.18	[5]	1.05	.20	1.34	Decrease in soil storage.
October	3.35	+.31	.22	1.38	[1].85	.31	2.73	Increase in soil storage.
November	2.50	+.15	.34	.49	[2]	.51	1.84	
December	4.10	−.08	[3].50	.42	[2]	[3].62	3.56	Increase in soil storage and perhaps in snow storage; estimate of total run-off may be too low.
1915								
January	6.49	+2.00	[3].95	2.95	[2]	[3]3.41	1.08	
February	5.63	+1.69	[3]1.20	2.89	[2]	[3]3.58	.36	
March	.10	−.38	1.19	.81	[2]	1.61	−1.13	Decrease in stream and snow storage.
April	1.88	−.614	.90	.29	[2]	1.60	.89	
May	3.15	−.23	.67	1.61	[1] 1.17	1.21	2.17	
June	1.88	−1.00	.28	[5]	.72	.45	2.43	
July	5.77	−.15	.24	[4].60	.51	.78	5.14	
August	7.87	+1.84	.60	3.34	[1].90	1.79	4.24	
September	2.56	−.31	.44	1.05	[1].93	.92	1.95	Decrease in soil storage.
October	2.61	−.92	.55	[4].50	.87	1.01	2.52	
November	2.51	−.15	.36	.21	[2]	.92	1.74	
December	4.86	+2.30	.73	3.03	[2]	2.90	−.34	Records for precipitation probably too low.
1916								
January	1.48	+.61	1.34	1.95	[2]	3.00	−2.13	Decrease in snow storage.
February	4.77	+1.00	.99	1.99	[2]	2.71	1.06	Increase in snow storage; records for precipitation probably too low.
March	2.43	+.38	1.16	1.54	[2]	3.66	−1.61	Decrease in snow storage; records for precipitation probably too low.
April	2.20	+.31	1.90	2.21	[2]	4.45	−2.56	Decrease in snow storage.
May	3.83	−.31	.89	[4] 1.84	1.26	1.76	2.38	
June	4.27	−1.84	.69	[4].40	1.55	1.68	4.43	
July	4.40	−1.00	.54	[4].40	.86	1.05	4.44	
August	4.67	−1.15	.29	[5]	.86	.56	5.26	
September	3.38	−1.00	.25	[2]	.81	.45	3.99	
October	1.29	−.77	.25	[4].30	.82	.44	1.62	
November	2.65	+.08	.32	.40	[2]	.56	2.01	Increase in soil storage.
December	3.52	+.84			[2]			

[1] Unsatisfactory estimate based on average of corresponding months in other years.
[2] Ground-water evaporation is regarded as negligible.
[3] Estimated on inadequate data.
[4] Estimated from irregularity in water-table curve in Plate 19.
[5] Ground-water recharge was apparently negligible in amount.

[1] Water-Supply Paper 597 B, U. S. Geological Survey, 1929.

Inventory of the average monthly water conditions in the Pomperaug Basin, July, 1913, to December, 1916, in depth in inches over the drainage area

[Based on all data in the preceding table]

Month	Precipitation [1]	Increase or decrease of ground water in storage	Ground-water run-off	Ground-water recharge	Ground-water evaporation	Total run-off	Total evaporation plus increase or minus decrease in surface and soil storage
October	4.12	+0.73	0.39	1.96	0.85	1.08	2.38
November	2.60	+.33	.69	1.05		1.18	1.05
December	3.77	+.71	.88	1.55		1.92	1.26
January	3.66	+.61	1.10	1.71		2.58	.47
February	4.50	+.79	.86	1.66		2.29	1.42
March	2.85	+.08	1.07	1.15		3.20	−.43
April	2.76	+.46	1.28	1.74		3.00	−.70
May	3.35	−.21	.80	1.76	1.17	1.77	1.78
June	3.09	−1.71	.45	.13	1.39	.92	3.88
July	4.50	−.87	.39	.48	.96	.84	5.34
August	4.80	−.03	.33	1.27	.90	.76	4.50
September	2.42	−.87	.26	.35	.93	.48	2.43

[1] Based on monthly precipitation during the period; not Waterbury normal.

Inventory of the annual water supply of the Pomperaug Basin, October, 1913, to September, 1916, in depth in inches over the drainage area

[Based on all data in the preceding table]

Month	Precipitation	Increase or decrease of ground water in storage	Ground-water run-off	Ground-water recharge	Ground-water evaporation	Total run-off	Total evaporation plus increase or minus decrease in surface and soil storage
October, 1913, to September, 1914	46.66	+0.45	9.05	16.84	7.34	21.04	25.17
October, 1914, to September, 1915	45.28	+3.23	7.53	15.83	5.07	16.79	25.26
October, 1915, to September, 1916	41.50	−1.83	9.69	14.07	6.21	24.15	19.18
Average	44.48	+.61	8.76	15.58	6.21	20.66	23.20

DISCUSSION OF METHODS AND RESULTS

In arid regions so many quantitative investigations of ground-water supplies have been made that the methods of work are relatively well understood. In humid regions, however, much less quantitative work has been done, the methods that are employed in arid regions are largely inapplicable, and the problem of making quantitative estimates is inherently more difficult. The method used in this investigation is a composite of several available methods and has doubtless led to more reliable results than could have been obtained by the application of any single method. The observations made, however, were not adequate in number nor sufficiently refined to lead to very accurate results, and the period of observations was too short to give average conditions. With the same general method much more accurate results can be obtained if sufficient funds and time are available to make more numerous and more detailed observations.

The precipitation records show that many of the rains and snows are local or vary in intensity within short distances, and that an accurate measure of the quantity of water that falls upon an area so large as the Pomperaug Basin can not be obtained from three rain gages, even though they are well distributed and there are no gaps in the records. Where so few gages are used the daily records are the most likely to be unrepresentative, but even the monthly and annual records may show considerably more or less precipitation than the true average for the basin. It should be noted, however, that with the method that was used the records of precipitation do not enter directly into the ground-water estimates.

In such an investigation the record of total run-off, as determined by the gaging station near the mouth of the trunk stream, is very important, and more money should be spent than was available for the station at Bennetts Bridge, to make this record accurate and complete. Instead of a staff gage read by a local observer once or twice a day, an automatic gage, or water-stage recorder, should be installed. In winter, when the relation of discharge to stage is disturbed by ice in the river, a sufficient number of current-meter measurements should be made to obtain a complete and reliable record.

In this investigation the estimates of ground-water run-off were based on the discharge of the Pomperaug at Bennetts Bridge—that is, on the discharge during the periods between rains, when there was virtually no direct run-off left in the stream system. Much better results could be obtained by basing the estimates on periods beginning as soon after rains as all of the direct run-off has reached the streams. With this method the ground-water run-off during any particular day would be the total run-off minus the decrease in stream storage. The decrease in stream storage could be estimated by maintaining gages at several points on the trunk stream and on selected tributaries and making surveys of the stream system showing the approximate water areas of different parts of the system at different gage heights. Calculations show that in a drainage basin which is not larger than the Pomperaug the total quantity of water stored in the stream system at any time is rather small compared with the rate of discharge and hence that errors in the measurement of decrease in storage will introduce relatively small errors in the estimates of ground-water run-off. The proposed method would have the advantage over the method used in this investigation in that the record would cover a much larger part of each period between rains and that the entire process would be one of observation and measurement without the intangible feature of the present method. It would not be necessary to make current-meter measurements to develop rating curves at the subsidiary stations, as only change in storage, indicated by change in gage height, is involved, not rate of discharge.

Records should be obtained in regard to snow storage and soil storage. The precipitation records should show whether the precipitation occurred as rain or snow, and there should be a record of the days when the snow contributed to the direct run-off, when it did not thaw sufficiently to contribute to the run-off, when the ground was virtually free of snow, and when the ground was frozen. Soil storage is an important item in the monthly inventory and could be estimated on the first of each month by making a number of moisture determinations of soil samples collected in fairly typical locations. Large numbers of moisture determinations are made in connection with dry-farming and irrigation investigations, and some are now made in the laboratories of the Geological Survey in connection with hydrologic investigations.

There should be a larger number of observation wells, they should be more widely distributed over the basin, and so far as possible they should be equipped with automatic water-stage recorders. Much more work should be done to determine the specific yield of the different kinds of material in which the water table occurs, because the specific yield is a factor in the estimates of ground-water recharge and ground-water evaporation. In recent investigations it has been found feasible to obtain columns of the undisturbed materials and to make direct tests of the specific yield of these materials in their natural state. The columns are taken directly above the water table at a low stage.

Records of evaporation from a free water surface should be obtained for the entire period covered by the investigation. Work could also be done in determining transpiration and soil evaporation by tank experiments and from daily fluctuations of the water table shown by water-stage recorders over wells. Indeed, with the methods that have been outlined, the accuracy of the results in a quantitative study of the water resources of an area will be largely a function of the funds and time available for making the investigation.

W. Peppler on characteristic features of air currents on coasts (*Meteorologische Zeitschrift, February, 1929*).—The remarks of W. Georgii and H. Koschmeider in *Heft* 8, *Meteorologische Zeitschrift*, 1928, lead me to make a few statements relative to the air currents on the coast of Flanders. In the course of the two years during which I was engaged in the work of the naval kite station at Breedene near Ostend, I had abundant opportunity to become acquainted with the interesting conditions of the current as it came from the open sea upon the land and also with the effect of the dunes upon the current. Although there was no opportunity to undertake special investigations of definite individual problems, the characteristic features of the coast as related to aerology forced themselves into notice at the times of the daily kite flights.

Especially with stormy west winds there was plainly observed the influences of the coast and the dunes in producing an intensification of disturbances in the air. For this reason and on account of the well known stormy character of the weather on the coast of the channel, the kite station suffered considerably until a certain adaptation of kite technique was taken up, and with a specially strong kite, constructed according to instructions from Herman John, there came success, even in a heavy storm, in launching and landing it for the most part undamaged. One can hardly imagine the terific wind velocities and the extraordinary turbulence that often prevail in the wind currents of the channel.

In a storm the following conditions were characteristic: If the west storm was from the open sea against the coast the wind velocities on the shore in front of the dunes were considerably greater than those at the kite station situated on a level plot of ground 300 meters behind the dunes. Despite the relatively slight elevation of the dunes (about 30 meters) their windbreak effect stretched inland at least 400 meters. Of course, it is to be taken into consideration that even on a flat shore the wind force decreases rapidly toward the interior on account of the sudden and marked increase in friction with the passage of the current from sea to land. There forms, so to speak, a pillow of air over which the succeeding masses of air must mount. Behind the dunes in the space where the conditions were affected by the windbreak there was an extraordinary increase in wind velocity, usually from 10 to 30 meters per second, from the ground to about 60 meters elevation, where in some cases 35 meters per second must have prevailed in so far as could be determined with any certainty from the course of the small storm kites. Generally it was observed that the kite entered more or less suddenly into an extremely turbulent current when it came to the elevation of the crests of the dunes. This stratum of turbulence had a thickness of about 100 meters. Above it the flow of air became somewhat more steady and in many cases the mean velocity decreased to increase again above some 500 meters. In the stratum of turbulence above the elevation of the crests of the dunes there pass in rapid succession over the relatively calm, lower stratum very strong whirls that bring marked oscillations in the readings of the dynamograph. These whirls evidently originate through friction and the damming of the current on the dunes.

In the current behind the dunes the following strata can be differentiated:

1. Relatively calm, less turbulent ground stratum that reaches to the height of the crests of the dunes. Here there is very marked increase in wind force upward from the ground.
2. Stratum of greatest turbulence between about 40 and 100 meters elevation. The lower and upper limits of this stratum are more or less plainly marked.
3. Stratum of moderate turbulence with wind velocity frequently decreasing upward.

In flights during stormy west winds the vertical temperature was such that up to from 50 to 100 meters above the ground (upper limit of the second stratum) there prevailed marked decrease in temperature (frequently 1° C. per 100 meters). In another paper [1] I have shown that for the average of many flights the vertical temperature gradient of the ground stratum increases in proportion to the wind velocity. As is well known, the cause is mechanical intermixing. Striking and unexpected to me, however, was the frequent observation that the temperature gradient decreased above the ground stratum and that there lay at from 50 to 100 meters elevation a slight inversion or then isothermacy. At first I thought this discontinuity the remnant of a nocturnal ground inversion; however, this view was not tenable since with cloudy weather and storm from the west inversions could neither form nor maintain themselves. Moreover, these discontinuities occurred with the afternoon flights also.

The fact that these discontinuities are not always present with westerly winds is explainable when they occur in the same manner as the mountain inversions cited by W. Georgii, occurring, thus, only when the lapse rate in the undisturbed current is less than 1° C. per 100 meters. In the storm the lapse rate in the ground stratum is often equal to or greater than 1° C. per 100 meters. The fact that this discontinuity, originating in the obstruction presented by the dunes, lies not directly at the crests of the dunes, but at a higher elevation is explained by the stratum of turbulence. One can conceive of the boundary between this and the upper undisturbed current as a kind of glide surface, although it is of a kind other than the glide surface between different bodies of air. In conclusion, I may mention that the upward wind over the dunes occasionally makes itself evident in fracto-nimbus cloudlets that form in strong wind over the dunes (and only there) at elevations of from 100 to 200 meters.

It is regrettable that the individual flights and the numerous interesting meteorological, aerological, and cloud observations contained in my war journal of over 5,000 pages could not be published on account of lack of funds. They contain, among other things, many interesting notes and observations on the air current and temperature conditions on coasts.—*Translated by W. W. Reed.*

Nile silt does not enrich the soil.—It has been held since the ages of the Pharaohs that silt enriches the soil and the classical example given is the Nile Valley. Comes along now Dr. E. McKenzie Taylor, of the School of Agriculture, University of Cambridge, England, who holds that the age-worn view is fallacious.[2] The editor of that journal in commenting upon the article rightly

[1] Aerologische und hydrographische Beobachtungen der deutschen Marine-Stationen während der Kriegzeit 1914 bis 1918. Die Beobachtungen der Marine-Drachenstationen Breedene Meer und St. Michel bei Brügge in den Jahren 19 15bis 1918. Heft 3 und 4. Deutsche Seewarte, Hamburg, 1922.

[2] E. McKenzie Taylor, Engineering News-Record, June 20, 1929.

points out that the deltaic plain of Egypt resembles the Imperial Valley of California, both being the creation of silt-laden streams and that millions of dollars have been expended in that valley to get rid of the silt.

Since Doctor Taylor is one of the first high authorities to question the value of Nile silt and since should further experiments corroborate his findings the effect would not only be far reaching but also it would justify the course followed by American engineers in the Imperial Valley of California.

Dr. Taylor's conclusions are:

1. A dressing of Nile silt without a summer fallow does not maintain crop yields.

2. A dressing of Nile silt following a summer fallow (as in the basin system of irrigation) does not increase crop yield.

3. The summer fallow is the effective agent in the maintenance of soil fertility under perennial irrigation.

4. Nile silt is not the agent responsible for the maintenance of soil fertility and has not the fertilizing properties previously attributed to it without investigation.—*A. J. H.*

A rare day in August.—The weather of August 4 in Washington, D. C., was exceptionally pleasant, coming as it did after 10 consecutive days with maximum temperature above 90° F. Nearly an inch of rain fell the night of the 3d–4th and the wind shifted to northwest, whence it blew all day of the 4th with a speed about 100 per cent above the average August speed. This combination, clear sky and fresh northwest winds, is rarely experienced in the summer months in Washington, D. C.

The barometric formations that led to this very agreeable change are of more than passing interest since they raise the age-old query, Why do cyclones at times increase in intensity? By intensity is meant an increase in the barometric gradient that materially strengthens the winds.

The barometric situation on the morning of August 2 was as follows: A trough of low pressure, axis, n/s stretched from eastern Nebraska to and beyond the Canadian border; in the southern end of the trough was a secondary cyclone with a closed isobar of 29.70 inches. Directly to the eastward an anticyclone with inner isobar of 30.10 inches covered Michigan and part of Lake Huron. The juxtaposition of these two formations doubtless gave to the secondary cyclone what may be called potential energy of position, since the winds on its eastern front were augmented and intensified by the circulation of the anticyclone, the wind direction in both circulations being substantially the same direction and thus they contributed to the convergence of air streams in the east front of the cyclone. The increase in intensity may be measured by the 12-hour pressure fall associated with the cyclone; on the morning of the 2d it was 0.16 inch, by the p. m. of the same day it had increased to 0.18 inch and by the a. m. of the 3d it was 0.28 inch and 2-hour pressure falls of 0.04 to 0.6 inch were reported from nine stations, thus showing a spreading of the pressure fall in the cyclone. On the morning of the 4th the central pressure fall had increased to 0.48 inch and one station reported a 2-hour fall of 0.12 inch; by this time the central isobar of the cyclone had dropped from 29.70 inches to 29.30 inches and the cool winds on its west side were fresh from the northwest bringing an agreeable respite from the high temperatures of the previous week or 10 days.—*A. J. H.*

Meteorological summary for Chile, July, 1929 (by J. Bustos Navarrete, Observatorio del Salto, Santiago, Chile).—This month was relatively dry in the central zone, and somewhat rainy in the southern part of Chile.

During the first days of the month there prevailed, generally, a régime of high pressure with variable weather in the south. Between the 7th and the 9th a relatively important depression crossed the extreme southern region and brought unsettled weather and rain between Concepcion and Chiloe. In the southern zone the unsettled conditions persisted until the 12th.

After an interval of calm another depression appearing from the west on the 15th caused general rains from Atacama to Chiloe on the 16th; on the following day the unsettled weather gave place and there was established an anticyclonic régime that continued, with variations, until the close of the month. In this period only one relatively important depression crossed the extreme south; this was accompanied by rain on the 27th extending north to Concepcion.

Monthly precipitation in inches was recorded as follows: At Santiago, 1.10; in the region of Concepcion, 2.87; and in the region of Valdivia, 21.02.—*Translated by W. W. R.*

BIBLIOGRAPHY

C. FITZHUGH TALMAN, in Charge of Library

RECENT ADDITIONS

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Bernheimer, W. E.
Das Problem der Veränderlichkeit der Sonnenstrahlung. Berlin. 1924. p. 452–475. figs. 23½ cm. (Probleme der Astron. Festschrift für Hugo v. Seeliger.)
Strahlung und Temperatur der Sonne. 56 p. figs. 25 cm. (Sonderab.: Handb. der Astrophys. Bd. 4. 1929.)

Carrier-Lyle corp.
Carrier weathermaker. How you can have perfect weather in your home all winter long. Newark. c1928. 19 p. illus. 28 cm.

Dannmeyer, F.
Grossstadtsonne und Ultraviolett-Glühlampe. 11 p. illus. 21 cm. (Sonderdr.: Die Umschau. 33. Jahrg. H. 29.)

Dorno, C., & Lindholm, F.
Zur Cadmiumzellen-Frage. 8 p. 35½ cm. [Manifolded.]
Zur Standard-Pyrheliometer-Frage. [Davos-Platz. 1929.] 7 p. 35½ cm. [Manifolded.]

Groissmayr, Fritz.
Die Nilflut und der Temperaturcharakter des Folgewinters in Leipzig. [Leipzig. 1928.] p. 326–333. figs. 24 cm. (Berichte: Verhandl. sächs. Akad. der Wissensch. zu Leipzig. Math.-phys. Kl. Bd. 80. 1928.)

Kassner, C.
Ueber trockene und nasse Zeiten in der Wachstumszeit des mittleren Norddeutschlands. Berlin. 1929. p. 429–451. fig. 25 cm. (Sonderdr.: Landwirtsch. Jahrb. Ztschr. für wissensch. Landwirtsch.)

Lindholm, F.
Registrierbeobachtungen der Hessschen Ultra-γ-Strahlung auf Muottas-Muraigl (2456 m). II. Mitteilung. Leipzig. 1929. p. 141–163. figs. 22½ cm. (Sonderdr.: Gerlands Beiträge zur Geophys. Bd. 22, H. ½.)

Mariolopoulos, E. G.
Sur la température à la surface du sol et à différentes profondeurs à Athènes. Athènes. 1928. p. xxii–xxix. figs. 29 cm. (Extr.: Annales de l'Observ. nat. d'Athènes. t. 10.)

Maurain, Ch., & *others*.
Données numeriques de physique du globe. Paris. 1928. vii, p. 1443–1502. figs. 27 cm. (Tables annuelles de constantes et données numeriques de chimie, de physique, de biologie et de technologie. v. 6, années 1923–1924.)

Petersen, Helge.
On the influence on the composition of the air of a possible high temperature in the highest strata of the atmosphere. København. 1928. 15 p. fig. 25 cm. (Pub. Danske met. inst. Comm. mag. no. 6.)

Poletika, W. v.
Agroklimatische Verhältnisse Russlands. 13 p. 24 cm. Sonderab.: Der Kulturtech. 31. Jahrg. H. 6. Nov./Dez. 1928.)

Taber, Stephen.
Frost heaving. p. 428–461. illus. 24½ cm. (Journ geol., v. 37, no. 5. July–Aug. 1929.)

U. S. Lighthouse service. Airways division.
Ceiling lights. 2 p. 26½ cm. (Instruc. bull., no. 64, Mar. 14, 1929.) [Manifolded.]
Radio broadcast of weather reports. 1929. v. p. plate. 28 cm. (Instruc. bull. D–5. Aug. 20, 1929.) [Manifolded.]

Whitlock, Herbert P.
Weather prophets of the sky. p. 251–260. illus. 25½ cm. (Nat. hist., v. 29, no. 3. May–June, 1929.)

SOLAR OBSERVATIONS

SOLAR AND SKY RADIATION MEASUREMENTS DURING AUGUST, 1929

By HERBERT H. KIMBALL, *Solar Radiation Investigations*

For a description of instruments and exposures and an account of the method of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, 1929, 57:26.

Table 1 shows that solar radiation intensities averaged below the normal values for August at all three stations.

Table 2 shows an excess in the total solar radiation (direct + diffuse) received on a horizontal surface at Washington, Madison, and Chicago, the excess at Washington exceeding 13 per cent. A deficiency is shown at Lincoln and New York.

Skylight polarization measurements obtained on four days at Washington give a mean of 54 per cent and a maximum of 58 per cent on the 2d. At Madison, measurements obtained on seven days give a mean of 51 per cent and a maximum of 63 per cent on the 15th. The values obtained at Washington are close to the August averages for that station. Those for Madison are nearly 10 per cent below the corresponding August averages, no doubt principally due to smoke from forest fires.

TABLE 1.—*Solar radiation intensities during August, 1929*

[Gram-calories per minute per square centimeter of normal surface]

Washington, D. C.

Date	Sun's zenith distance: 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th meridian time	Air mass: A. M.					P. M.				Local mean solar time
	e.	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Aug. 1	17. 96					1. 03					15. 11
Aug. 2	10. 97					1. 28					7. 87
Aug. 5	8. 81		0. 84								6. 50
Aug. 16	10. 21	0. 44	0. 55	0. 70	0. 90						9. 14
Aug. 17	12. 24	0. 41	0. 50	0. 62	0. 82						12. 24
Aug. 20	7. 87	0. 61	0. 74	0. 91	1. 09	1. 33	1. 01	0. 83	0. 78		7. 57
Aug. 21	10. 59				0. 86	0. 93					7. 04
Aug. 26	13. 13			0. 85	1. 01	1. 25	1. 01	0. 75	0. 58	0. 45	9. 14
Aug. 31	10. 21	0. 60	0. 68	0. 82	1. 06						7. 57
Means		0. 52	0. 66	0. 78	0. 96	1. 16	(1. 01)	(0. 79)	(0. 68)	(0. 45)	
Departures		−0. 10	−0. 01	+0. 03	+0. 04	−0. 06	−0. 01	−0. 08	−0. 05	−0. 18	
Madison, Wis.											
Aug. 7	11. 81				0. 91	1. 14					10. 97
Aug. 10	15. 65			0. 59	0. 82						17. 37
Aug. 15	8. 48			1. 04	1. 19	1. 37					8. 48
Aug. 19	8. 48			0. 97	1. 12	1. 29					9. 47
Aug. 23	10. 97					1. 19					10. 59
Aug. 24	12. 24			0. 63	0. 84	1. 16					14. 10
Aug. 27	9. 14			0. 86	1. 03	1. 38					8. 48
Aug. 31	11. 38			0. 62	0. 79	1. 20					12. 24
Means				0. 78	0. 96	1. 25					
Departures				−0. 16	−0. 14	−0. 06					

[1] Extrapolated.

TABLE 1.—*Solar radiation intensities during August, 1929*—Contd

[Gram-calories per minute per square centimeter of normal surface]

Lincoln, Nebr.

Date	Sun's zenith distance: 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th meridian time	Air mass: A. M.					P. M.				Local mean solar time
	e.	5.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Aug. 5	11. 38						0. 89	0. 78	0. 62		13. 61
Aug. 23	15. 65					1. 31	0. 92	0. 72	0. 58	0. 48	17. 37
Aug. 24	15. 65					1. 28					14. 10
Means						(1. 30)	(0. 90)	(0. 75)	(0. 60)	(0. 48)	
Departures						±0. 00	−0. 17	−0. 14	−0. 16	−0. 22	

TABLE 2.—*Solar and sky radiation received on a horizontal surface*

[Gram-calories per square centimeter of horizontal surface]

Week beginning—	Average daily radiation: Washington	Madison	Lincoln	Chicago	New York	Twin Falls	Fresno	La Jolla	Average daily departure from normal: Washington	Madison	Lincoln	Chicago	New York
1929	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
July 30	558	494	492	361	381	556	687	394	+109	+31	−29	−5	+11
Aug. 6	394	463	450	374	307	----	658	459	−40	+7	−54	+18	−39
Aug. 13	529	464	527	415	298	----	585	449	+97	+24	+32	+53	−33
Aug. 20	522	433	499	362	359	----	609	460	+109	−2	+14	−6	+45
Aug. 27	436	416	468	351	303	----	606	443	+11	+8	+6	−6	−14
Excess or deficiency since first of year on Sept. 2									+5, 152	−672	−2, 050	−441	−4, 109

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. C. S. Freeman, Superintendent U. S. Naval Observatory. Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, and Mount Wilson observatories. The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column]

Date	Eastern standard civil time	Heliographic: Diff. long.	Longitude	Latitude	Area: Spot	Group	Total area for each day
1929	h. m.	°	°	°			
Aug. 1 (Naval Observatory)	10 59	−62. 5	288. 8	−3. 5	----	185	----
		−9. 0	342. 3	+21. 5	----	37	----
		+30. 0	21. 3	+9. 0	----	15	----
		+42. 0	33. 3	−21. 0	----	154	----
		+46. 5	37. 8	−11. 0	9	----	----
		+64. 0	55. 3	−11. 0	----	62	----
		+76. 5	67. 8	+7. 0	31	----	493
Aug. 2 (Naval Observatory).	11 32	−48. 0	289. 7	−3. 5	----	154	----
		−19. 0	318. 7	+12. 5	----	9	----
		+6. 5	344. 2	+21. 0	22	----	----
		+11. 0	348. 7	−12. 5	----	25	----
		+33. 0	10. 7	+9. 0	3	----	----
		+46. 0	23. 7	+9. 0	6	----	----
		+56. 0	33. 7	−21. 0	----	123	----
		+79. 0	56. 7	−11. 5	46	----	388

Positions and areas of sun spots—Continued

Date	Eastern standard civil time	Heliographic			Area		Total area for each day
		Diff. long.	Longitude	Latitude	Spot	Group	
1929	h. m.	°	°	°			
Aug. 3 (Mount Wilson)	13 0	−35.0	288.7	−5.0		221	
		−5.0	318.7	+12.0		7	
		+18.0	341.7	+21.0		4	
		+61.0	24.7	+10.0		4	
		+70.0	33.7	−20.0		57	293
Aug. 4 (Naval Observatory).	10 57	−42.0	269.6	−2.0		108	
		−21.0	280.6	−3.5		185	293
Aug. 5 (Naval Observatory).	10 44	−86.0	212.5	−9.0	185		
		−68.0	230.5	−22.0		31	
		−28.0	270.5	−2.5		77	
		−7.5	291.0	−3.5		185	
		+48.0	346.5	−13.5		31	509
Aug. 6 (Naval Observatory).	10 38	−83.0	202.3	−16.0	123		
		−70.0	215.3	−10.0	123		
		−57.0	228.3	−21.5		62	
		−15.5	269.8	−3.0		31	
		+6.5	291.8	−4.0		185	
		+64.5	349.8	−13.0	9		533
Aug. 7 (Naval Observatory).	12 14	−69.5	201.7	−15.5	123		
		−56.5	214.7	−9.5	108		
		−42.0	229.2	−21.0		52	
		+21.0	292.2	−4.0		170	
		+38.5	309.7	+12.5	9		462
Aug. 8 (Naval Observatory).	14 58	−56.5	200.0	−15.0		108	
		−41.5	215.0	−8.5		139	
		−25.0	231.5	−19.5		31	
		+28.0	284.5	+8.5		22	
		+36.0	292.5	−3.5		123	423
Aug. 9 (Naval Observatory).	10 49	−45.0	200.6	−15.0		108	
		−30.0	215.6	−9.0	123		
		−13.5	232.1	−19.5		31	
		+38.5	284.1	+8.5		62	
		+48.5	294.1	−4.0		123	
		+68.0	313.6	+12.5		93	540
Aug. 10 (Naval Observatory).	10 45	−80.0	152.4	+3.0		93	
		−75.0	157.4	−10.0	9		
		−32.5	199.9	−16.0		154	
		−17.5	214.9	−9.0	185		
		0.0	232.4	−19.5	15		
		+53.5	285.9	+8.0		62	
		+63.5	295.9	−5.0		108	
		+79.5	311.9	+12.5		77	703
Aug. 11 (Naval Observatory).	10 45	−65.5	153.7	+3.5		46	
		−61.0	158.2	−10.0	6		
		−18.5	200.7	−15.5		123	
		−3.0	216.2	−9.5	154		
		+3.0	222.2	+20.5		46	
		+13.5	232.7	−19.5	3		
		+68.5	287.7	+7.0	31		
		+77.0	296.2	−5.0	123		532
Aug. 12 (Naval Observatory).	10 51	−52.0	153.9	+3.0		93	
		−50.0	155.9	−7.5		62	
		−47.0	158.9	−11.0	15		
		−34.0	171.9	−20.5	3		
		−6.5	199.4	+8.5	3		
		−5.5	200.4	−15.5	77		
		+10.0	215.9	−9.5	154		
		+18.0	223.9	+20.5	22		
		+41.0	246.9	−7.0	6		
		+80.0	285.9	+5.0	22		457
Aug. 13 (Naval Observatory).	10 59	−38.5	154.1	+3.0		123	
		−35.5	157.1	−8.0		185	
		−33.5	159.1	−11.0	3		
		−11.5	181.1	−18.5	3		
		−1.5	191.1	+21.5	6		
		+7.0	199.6	−15.5		123	
		+23.0	215.6	−9.5	139		
		+32.5	225.1	+21.0	6		588
Aug. 14 (Naval Observatory).	10 50	−44.0	135.5	+18.5	3		
		−30.5	149.0	+7.5	25		
		−26.5	153.0	+18.5		6	
		−26.0	153.5	+3.0		123	
		−22.0	157.5	−8.0		340	
		+2.0	181.5	−19.0		108	
		+13.0	192.5	+21.5		62	
		+21.0	200.5	−15.5		62	
		+36.5	216.0	−10.0	123		852
Aug. 15 (Naval Observatory).	10 45	−78.5	87.8	+1.5	46		
		−74.5	91.8	−6.0	62		
		−61.0	105.3	+15.0	3		
		−17.0	149.3	+7.5	19		
		−12.5	153.8	+19.0		6	
		−12.5	153.8	+3.0		154	
		−8.5	157.8	−8.0		417	
		+14.5	180.8	−19.0		108	
		+27.5	193.8	+22.0		93	
		+33.5	199.8	−15.5	55		
		+50.0	216.3	−9.5	93		1,056

Positions and areas of sun spots—Continued

Date	Eastern standard civil time	Heliographic			Area		Total area for each day
		Diff. long.	Longitude	Latitude	Spot	Group	
1929	h. m.	°	°	°			
Aug. 16 (Naval Observatory).	10 45	−68.0	85.1	+2.0		139	
		−68.0	85.1	−15.0		93	
		−60.0	93.1	−5.5	62		
		−46.5	106.6	+3.0	3		
		−3.0	150.1	+7.5	19		
		+1.0	154.1	+3.5		123	
		+5.0	158.1	−8.5		448	
		+28.5	181.6	−19.5		139	
		+42.0	195.1	+22.0		77	
		+47.0	200.1	−15.5	31		
		+63.5	216.6	−9.5	62		1,196
Aug. 17 (Naval Observatory).	10 47	−55.5	84.3	−14.5		77	
		−54.5	85.3	+2.0		123	
		−47.0	92.8	−5.0	46		
		+15.0	154.8	+3.5		62	
		+18.5	158.3	−7.5		448	
		+42.5	182.3	+14.5		46	
		+43.0	182.8	−18.5		170	
		+55.5	195.3	+22.5		93	
		+60.5	200.3	−15.0	19		
		+76.5	216.3	−9.0	62		1,146
Aug. 18 (Naval Observatory).	10 42	−42.5	84.2	+2.0		77	
		−42.0	84.7	−14.5		77	
		−34.0	92.7	−4.5		43	
		+28.5	155.2	+3.5		25	
		+32.0	158.7	−7.5		463	
		+57.0	183.7	−18.5		154	
		+58.0	184.7	+13.5		108	
		+69.5	196.2	+22.5		123	
		+73.5	200.2	−16.0	15		1,085
Aug. 19 (Naval Observatory).	10 53	−47.5	65.8	−6.5	6		
		−42.5	70.8	−19.5		12	
		−28.5	84.8	+2.0		25	
		−27.0	86.3	−14.5		77	
		−21.0	92.3	−4.5		46	
		−10.0	103.3	+15.0	9		
		+46.5	159.8	+3.5	3		
		+46.5	159.8	−7.5		417	
		+70.5	183.8	−18.5		170	
		+73.0	186.3	+12.0		123	
		+85.0	198.3	+22.0	154		1,042
Aug. 20 (Naval Observatory).	10 45	−32.0	68.2	−6.5	6		
		−28.5	71.7	−19.5		25	
		−9.5	90.7	−13.5		77	
		−7.5	92.7	−5.0		34	
		+2.5	102.7	+15.0		93	
		+60.5	160.7	−7.5		340	
		+80.0	180.2	−22.0	62		637
Aug. 21 (Naval Observatory).	10 45	−31.5	55.5	+27.5		37	
		−17.5	69.5	−6.0	3		
		−15.0	72.0	−19.0		93	
		−2.0	85.0	+3.0		9	
		+4.0	91.0	−13.5	62		
		+5.5	92.5	−5.0	19		
		+15.5	102.5	+15.0		123	
		+45.0	132.0	+18.5	3		
		+74.5	161.5	−7.5		340	689
Aug. 22 (Naval Observatory).	10 44	−58.5	15.3	+11.0	9		
		−5.5	68.3	−6.5		9	
		−1.5	72.3	−19.0		170	
		+18.0	91.8	−13.5	46		
		+19.0	92.8	−5.0	12		
		+31.0	104.8	+15.0		108	354
Aug. 23 (Naval Observatory).	13 44	−44.0	14.9	+8.5	12		
		−30.0	28.9	+23.0	3		
		−8.5	50.4	+36.0	3		
		+8.0	66.9	−7.0		22	
		+13.0	71.9	−19.5		201	
		+32.5	91.4	−13.0	46		
		+33.5	92.4	−5.5	9		
		+46.5	105.4	+15.0		123	419
Aug. 24 (Naval Observatory).	10 45	−39.5	7.8	−0.5	6		
		−36.0	11.3	+12.0		15	
		+21.5	68.8	−7.5		25	
		+24.5	71.8	−19.5		185	
		+44.5	91.8	−13.0		49	
		+45.5	92.8	−5.5	9		
		+62.0	109.3	+15.0	77		366
Aug. 25 (Naval Observatory).	12 11	−37.0	356.3	−9.0	3		
		−14.0	19.3	+22.5	3		
		−7.0	26.3	−10.0	3		
		+36.5	69.8	−6.0		139	
		+39.0	72.3	−19.0		154	
		+58.5	91.8	−13.0		77	
		+59.5	92.8	−6.0	6		
		+76.5	109.8	+15.0	77		462
Aug. 26 (Naval Observatory).	10 46	−26.0	354.9	−8.0		15	
		+50.5	71.4	−5.5		154	
		+51.5	72.4	−19.5		108	
		+72.0	92.9	−13.0	25		302

Positions and areas of sun spots—Continued

Date	Eastern standard civil time	Heliographic			Area		Total area for each day
		Diff. long.	Longitude	Latitude	Spot	Group	
1929	h. m.	°	°	°			
Aug. 27 (Naval Observatory).	11 3	−13.0	354.5	−7.0	.....	34	.....
		+64.5	72.0	−5.5	.....	123	.....
		+66.5	74.0	−19.5	.....	93	250
Aug. 28 (Naval Observatory).	12 15	−24.0	329.7	+4.0	.....	9	.....
		+1.5	355.2	−7.0	.....	19	.....
		+79.0	72.7	−5.0	.....	123	.....
		+82.0	75.7	−19.5	.....	93	244
Aug. 29 (Naval Observatory).	11 31	−13.0	327.9	+4.5	6	.....	.....
		+15.0	355.9	−7.0	.....	46	52
Aug. 30 (Naval Observatory).	11 30	−26.5	301.2	−13.5	6	.....	.....
		+29.0	356.7	−7.5	.....	46	52
Aug. 31 (Naval Observatory).	11 20	−17.0	297.5	+2.0	6	.....	.....
		−5.5	309.0	−37.5	6	.....	.....
		+14.5	329.0	+4.0	6	.....	.....
		+43.0	357.5	−7.0	.....	6	24
Mean daily area for August							530

PROVISIONAL SUN-SPOT RELATIVE NUMBERS FOR AUGUST, 1929 [1]

[Data furnished through the courtesy of Prof. W. Brunner, University of Zurich, Switzerland]

August, 1929	Relative numbers	August, 1929	Relative numbers	August, 1929	Relative numbers
1	66	11	[2] [3] E 62	21	.....
2	[2] 70	12	[2] 74	22	[2] 74
3	47	13	[2] [3] M 76	23	[3] M 67
4	[3] E 37	14	[3] M 101	24	54
5	41	15	132	25	54
6	[2] [4] 56	16	[2] [5] 125	26	[3] E 47
7	[4] 61	17	115	27	32
8	48	18	[3] W 107	28	32
9	54	19	43	29	27
10	[3] M 61	20	[3] E	30	28
				31	10

Mean, 29 days=62.1.

[1] Dependent alone on observations at Zurich and its station at Arosa.
[2]= Passage of an average-sized group through the central meridian.
[3]= New formation of a large or average-sized center of activity—E, on the eastern part of the sun's disk; W, on the western part; M, in the central zone.
[4]= Entrance of a large or average-sized center of activity on the east limb.
[5]= Passage of a large group through the central meridian.

AEROLOGICAL OBSERVATIONS

By RICHMOND T. ZOCH

Free-air temperatures were above normal at all levels at Broken Arrow, Ellendale, and Groesbeck and mostly below normal at Due West, Royal Center, and Washington. (See Table 1.)

Free-air relative humidities were below normal and nearly all levels at all stations. Vapor pressures were also mostly below normal, although in a few cases the departures were small. The total precipitation for the month was below normal at all of these stations.

From the 1,000-meter level to the highest levels observed the resultant winds over the northern and eastern part of the country had a northerly component. (See Table 2.) Over the western part of the country the resultant winds were variable to the 2,000-meter level, above which a southerly component prevailed.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during August, 1929*

TEMPERATURE (°C.)

Altitude m. s. l.	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)		Washington, D. C. (Naval air station) (7 meters)	
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
Meters												
Surface	26.5	−0.2	25.5	−0.4	21.2	+1.0	24.7	−2.1	19.9	−3.6	24.8	+0.3
500	25.5	+0.2	23.3	+0.1	21.2	+1.2	24.4	+0.1	18.3	−2.9	20.8	−1.1
1,000	24.0	+1.1	20.3	+0.2	19.9	+1.8	22.6	+0.4	15.9	−2.1	18.5	−0.9
1,500	20.8	+1.0	17.4	+0.3	18.0	+2.5	20.1	+0.6	13.3	−1.8	15.9	−0.5
2,000	17.5	+1.1	13.8	−0.3	16.1	+3.5	16.9	+0.3	10.9	−1.4	13.2	−0.4
2,500	14.3	+1.3	10.8	−0.3	13.6	+4.0	13.7	0.0	8.3	−1.4	10.4	−0.4
3,000	11.2	+1.4	7.7	−0.7	10.6	+4.0	11.2	+0.2	5.5	−1.4	8.2	+0.1
4,000	.....	.....	−1.0	−3.7	4.0	+3.2	5.9	0.0	0.9	−0.7	3.7	+2.3

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during August, 1929*—Continued

RELATIVE HUMIDITY (%)

Altitude m. s. l.	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)		Washington, D. C. (Naval air station) (7 meters)	
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
Meters												
Surface	60	−7	69	0	61	−5	76	+3	70	+3	65	−7
500	57	−7	68	−3	59	−5	66	−8	64	−2	66	−3
1,000	54	−7	69	−3	49	−9	52	−10	61	−6	62	−4
1,500	55	−6	70	−1	46	−11	49	−11	56	−9	63	−5
2,000	54	−9	72	+3	44	−11	54	−5	49	−12	62	−6
2,500	54	−9	60	−7	43	−11	50	−7	52	−3	57	−8
3,000	51	−12	59	−7	42	−12	44	−9	50	−1	52	−8
4,000	.....	.....	66	−4	34	−16	40	+1	55	+9	61	−3

VAPOR PRESSURE (*mb.*)

Surface	20.52	−2.47	22.41	−0.34	14.81	−0.33	23.52	−1.81	16.24	−3.01	20.69	−1.68
500	18.44	−1.99	19.24	−0.78	14.42	−0.34	19.71	−2.49	13.64	−3.16	16.64	−1.94
1,000	15.95	−0.75	16.22	−0.55	11.08	−0.78	14.21	−2.32	11.07	−2.98	13.68	−1.48
1,500	13.46	−0.43	13.85	+0.01	8.96	−0.86	11.38	−2.16	8.52	−2.91	11.87	−1.09
2,000	10.73	−0.87	11.20	+0.06	7.50	−0.39	10.71	−0.48	6.41	−2.48	9.82	−0.96
2,500	8.65	−0.70	7.56	−1.39	6.34	−0.08	8.74	−0.42	5.69	−0.96	7.49	−0.92
3,000	6.81	−0.66	6.02	−1.31	5.25	−0.07	7.44	+0.06	4.71	−0.39	5.78	−0.46
4,000	.....	.....	3.83	−1.54	2.52	−0.96	6.20	+2.01	3.75	+0.51	4.61	+1.24

The total number of observations made during the month (see Table 3) includes 5 captive balloons and 21 limited-height sounding-balloon flights.

TABLE 2.—*Free-air resultant winds (meters per second) based on pilot balloon observations made near 7 a. m. (E. S. T.) during August, 1929*

Altitude m. s. l.	Broken Arrow, Okla. (233 meters)		Burlington, Vt. (132 meters)		Cheyenne, Wyo. (1,868 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Havre, Mont. (762 meters)		Jacksonville, Fla. (65 meters)		Key West, Fla. (11 meters)		Los Angeles, Calif. (40 meters)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
Meters	°		°		°		°		°		°		°		°		°		°	
Surface	S 15 E	1.4	S 32 W	1.8	N 79 W	2.2	N 43 E	0.7	N 12 W	1.0	S 17 W	1.6	S 63 W	3.4	S 70 W	0.9	S 59 E	2.2	N 73 W	1.9
500	S 13 W	6.1	S 68 W	3.7	----------	-----	N 8 E	1.3	N 46 E	0.7	S 38 W	7.6	----------	-----	S 90 W	2.6	S 60 E	5.2	S 74 E	1.2
1,000	S 48 W	7.0	N 82 W	5.2	----------	-----	N 12 W	1.9	S 24 W	1.8	S 16 W	4.6	S 37 W	2.0	S 77 W	2.7	S 59 E	4.6	N 7 W	0.6
1,500	S 66 W	4.2	N 82 W	5.2	----------	-----	N 54 W	2.7	N 70 W	1.7	S 23 E	2.9	S 73 W	3.4	S 69 W	2.2	S 52 E	4.0	N 80 W	0.7
2,000	N 89 W	2.2	N 75 W	6.3	S 85 W	3.4	N 64 W	3.7	N 71 W	3.1	S 76 E	3.0	S 83 W	4.7	S 66 W	2.2	S 54 E	3.1	S 45 W	2.1
2,500	N 57 W	1.8	N 79 W	6.6	S 75 W	3.2	N 70 W	4.4	N 69 W	5.2	N 86 E	3.0	S 84 W	5.7	S 55 W	2.1	S 51 E	2.6	S 21 W	2.9
3,000	N 18 E	1.5	N 68 W	7.8	S 88 W	3.8	N 72 W	4.3	N 65 W	6.3	N 83 E	3.4	S 82 W	7.2	S 61 W	2.1	S 67 E	2.4	S 4 E	4.2
4,000	N 43 E	2.0	N 69 W	8.8	N 84 W	3.2	N 74 W	5.5	N 50 W	9.4	N 89 E	4.0	S 82 W	9.7	S 38 W	1.6	S 45 E	2.4	S 29 E	4.7
5,000	N 14 E	2.1	----------	-----	N 55 W	2.8	N 71 W	5.6	N 47 W	7.6	S 71 E	4.6	S 87 W	12.5	S 45 W	1.4	S 34 E	1.6	S 7 W	1.3

	Medford, Oreg. (446 meters)		Memphis, Tenn. (145 meters)		New Orleans, La. (25 meters)		Omaha, Nebr. (313 meters)		Royal Center, Ind. (225 meters)		Salt Lake City, Utah (1,280 meters)		San Francisco, Calif. (60 meters)		Sault Ste. Marie, Mich. (198 meters)		Seattle, Wash. (67 meters)		Washington, D. C. (34 meters)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
Meters	°		°		°		°		°		°		°		°		°		°	
Surface	S 26 E	1.2	S 67 E	1.1	N 11 W	0.5	S 59 E	1.0	S 36 E	0.7	S 27 E	3.3	S 58 W	2.2	N 45 E	0.2	S 62 E	1.6	N 26 W	0.7
500	S 30 E	0.9	S 76 W	0.1	N 46 W	2.5	S 13 E	3.8	S 26 W	1.9	----------	-----	S 45 W	3.5	S 73 W	1.9	S 28 E	1.5	N 23 W	2.8
1,000	N 78 W	0.4	N 55 W	2.3	N 45 W	0.6	S 37 W	4.7	N 72 W	1.9	----------	-----	S 82 W	4.6	N 74 W	4.3	S 61 E	0.4	N 35 W	2.9
1,500	S 84 E	0.9	N 59 W	3.7	S 68 E	1.0	S 87 W	4.1	N 53 W	4.4	S 25 E	5.8	S 38 W	4.0	N 61 W	5.2	N 67 W	0.6	N 60 W	4.5
2,000	S 3 W	2.4	N 34 W	2.9	S 82 E	1.4	N 74 W	3.9	N 53 W	6.1	S 7 E	4.8	S 41 W	4.5	N 61 W	5.9	N 83 W	3.1	N 61 W	5.4
2,500	S 18 W	6.3	N 9 W	3.6	S 80 E	1.6	N 70 W	4.5	N 50 W	7.0	S	3.0	S 25 W	5.6	N 46 W	8.2	N 86 W	4.2	N 53 W	5.9
3,000	S 20 W	8.3	N	3.5	N 61 E	1.8	N 62 W	5.8	N 48 W	7.2	S 11 W	3.3	S 39 W	4.5	N 37 W	7.8	S 78 W	4.3	N 49 W	5.4
4,000	S 25 W	10.9	N 22 W	2.9	N 55 E	2.1	N 68 W	6.8	N 54 W	7.0	S 36 W	4.6	----------	-----	N 20 W	8.3	----------	-----	N 9 W	8.5
5,000	----------	-----	N 46 W	3.1	N 60 E	2.2	N 59 W	7.6	N 39 W	6.3	S 54 W	5.6	----------	-----	----------	-----	----------	-----	----------	-----

TABLE 3.—*Observations by means of kites, captive and limited-height sounding balloons, and airplanes during August, 1929*

	Broken Arrow, Okla.	Due West, S. C.	Ellendale, N. Dak.	Groesbeck, Tex.	Royal Center, Ind.	Naval Air Station, D. C.
Mean altitudes (meters), m. s. l., reached during month	2,404	2,118	2,809	1,854	2,659	3,323
Maximum altitude (meters), m. s. l., reached and date	[1] 3,705	[2] 4,120	[3] 4,824	[4] 4,699	[5] 4,693	[6] 4,002
Number of flights made	29	24	30	27	20	17
Number of days on which flights were made	29	23	26	27	20	17

[1] 14th. [2] 4th. [3] 31st. [4] 21st. [5] 15th. [6] 6th.

In addition to the above there are approximately 100 pilot-balloon observations made daily at 45 Weather Bureau stations in the United States.

WEATHER IN THE UNITED STATES

THE WEATHER ELEMENTS

By P. C. Day

GENERAL SUMMARY

August, 1929, was notable mainly for the wide extent and persistence of the drought conditions that prevailed in practically all parts of the country, save in a few States embracing the territory from the southern Rocky Mountains westward to the Pacific coast.

In many sections where drought existed during August there had been little precipitation during the latter part of the previous July, and the absence of any extensive precipitation during August resulted in drought conditions of unusual severity, causing marked deterioration in crop growth over considerable areas.

Other weather conditions were not abnormal to any important extent, and the month, as a whole, was comparatively cool in many sections and favorable for outdoor activities in practically all parts of the country.

PRESSURE AND WINDS

The pressure distribution during the month was unfavorable for the development of active cyclones, and, as in July, these storms were infrequent and maintained their identity as such for only short periods.

The month opened with a slight barometric depression passing into the lower St. Lawrence Valley attended by light precipitation in the Canadian Maritime Provinces and the northern portions of New York and New England, and showers, some comparatively heavy, had fallen during the previous 24 hours locally in the Gulf States and the southern drainage area of the Ohio. The following day falling pressure overspread the central Great Plains and local showers occurred over portions of the Dakotas and southeastward to southern Lake Michigan, and widely scattered light rains continued in the Gulf States and occurred at points along the Atlantic coast. The depression over the central Plains moved eastward to the lower Lake region by the morning of the 3d, attended by general rains from the upper Mississippi Valley eastward to and including much of the Ohio Valley. This storm moved to northward of the lower St. Lawrence Valley by the morning of the 4th, and rain occurred from the lower Lakes and Ohio Valley northeastward to the Atlantic coast and the adjoining Canadian Provinces.

Another low-pressure area (cyclonic storm) had formed over the lower Missouri Valley by the morning of the 5th, attended by showers at points near the center, and had moved southeasterly by the morning of the 6th, but precipitation was still limited to small areas near and to northward of the center, the largest recorded fall (nearly 3 inches) occurring at St. Louis. This storm appears to have lost energy quickly and by the morning of the 7th had largely dissipated.

No important depression of the barometer occurred thereafter until about the 12th, though local showers were recorded each day somewhere within the area from the Rocky Mountains eastward, but the amounts were mainly small and contributed but little useful moisture save near the east Gulf and Atlantic coast districts about the 12th.

By the morning of the 13th a disturbance (cyclonic storm) was central over Lake Superior and scattered showers had occurred from the valley of the Red River of the North eastward to Michigan, though they, too, were mostly light; but farther south local showers, some heavy, had also occurred from Arkansas eastward to the coast. During the following two days the cyclonic conditions over Lake Superior moved northeastward and finally entered the lower St. Lawrence Valley, giving some good rains locally in the Northeast sections, while the rainy conditions existing in the Gulf States moved eastward and by the morning of the 15th had generally disappeared, at which time clear weather existed in nearly all parts of the country.

No precipitation of consequence was recorded thereafter until the morning of the 19th, when local storms were reported quite generally along the Atlantic coast from Key West to Boston. On the following two days precipitation continued over the southern portion of this district and again on the 22d, extending at this time westward to the Texas coast. Local showers became more prevalent on the 23d, occurring over a rather narrow strip from Arizona northeastward to the vicinity of southern Lake Michigan and thence southeasterly to near the middle Atlantic coast, and showers continued in the Gulf coast districts. The amounts of precipitation over these areas were usually small, however, and afforded only slight relief in important drought areas.

Some showers occurred over a considerable area from the Ohio Valley northeastward to the middle Atlantic coast and New England on the 24th and from eastern Texas to the Carolina coast on the 25th, and locally in parts of Florida on the 26th, 27th, and 28th and at a few other points, particularly in the Southwest, but otherwise there was little precipitation until the end of the month, at which time the severe drought still existing over the major portions of the country was practically unrelieved.

Anticyclones dominated much of the country during the month, favoring dry and cool weather for the period of the year, but they were not sufficiently strong to cause important frosts.

The average pressure for the month, reduced to sea level, was comparatively high and above normal in all portions of the United States and Canada, save over a narrow strip along the coast from Florida northeastward to the eastern Canadian Provinces and over a small area in the northern plateau region. The changes from similar values of July were mostly small, the August pressures being generally less than those for July from Texas and Oklahoma northeastward to the St. Lawrence Valley and over the immediate Pacific coast and the far Northwest. Over most interior districts the pressures for August were higher than those for July.

Local storms were infrequent, but were severe in a few localities, material damage from hail to the tobacco crop occurring in the vicinity of Hartford, Conn., on the 1st and in portions of Wisconsin on the 13th. Tornadoes occurred at a few points, but they were not severe and no deaths resulted therefrom, though five persons lost their lives in other wind storms. The details of damaging storms appear at the end of this section.

73997—29——3

TEMPERATURE

In many central and eastern districts August was a distinctly pleasant month as concerned the temperature and even in the Middle West frequent changes from cool to warm, or vice versa, made the weather comfortable on the whole. In the far Northwest, however, the weather was warm almost throughout; at some points the daily averages were normal or above nearly every day; and in several States the monthly means for the entire State were the highest of record.

The changes in temperature from day to day were mainly small, but sufficient usually to give welcome physical variation. In only one period, 24th–25th, was the daily change in excess of 20°; this occurred in the valley of the Red River of the North, when unusually cool weather for the season overspread most sections of the Northwest and frosts were recorded at a number of points, but no material damage to crops was sustained.

The average temperature for the month was below the normal over nearly all districts from the Mississippi River eastward save in portions of the Middle Gulf States, the deficiency ranging up to as mush as 4° in the Ohio Valley and Northeastern States.

West of the Mississippi Valley the temperatures were everywhere above the normal and decidedly so in the Plateau and northern Rocky Mountain States, where they ranged generally from 4° to 7° above.

The highest temperatures in most eastern and central districts occurred early in the month or during the last decade, while in the far West they occurred mostly in the second and last decades. The highest mark, 122°, was recorded in southern California on the 12th, but temperatures ranging from 105° to 115° occurred somewhere in practically all the States west of the Mississippi River. East of that river the highest temperatures usually did not rise to 100°, save in the Southern States.

The lowest temperatures were recorded mainly during the last two decades and most frequently near the middle of the month. Minimum temperatures below freezing were recorded at points along the entire northern border, the lowest reported anywhere being 22° at a point in the high portion of Oregon.

PRECIPITATION

Not in many years has the precipitation for August been so widely deficient as during August, 1929. Probably 90 per cent of the entire area had less than normal amounts, and this condition was greatly intensified by marked deficiencies in precipitation over many of the same sections during the latter part of the preceding July.

In a few localities the total precipitation was less than received in any August over more than 50 years, while at other points it was near to if not quite the least. Slight excesses in precipitation was experienced in portions of the Southwest, and small positive departures from the normal were recorded over a few scattered areas in other parts of the country, some heavy falls occurring over a considerable portion of central Iowa, particularly, on the 1st and 2d, the heaviest occurring in Tama County, where a fall of 8.27 inches occurred within a period of about two hours. This was probably the heaviest rain ever experienced in the State during so short a period of time, causing streams in the immediate vicinity to rise to or above the highest stages ever known and resulting in much damage to roads, bridges, and otherwise.

RELATIVE HUMIDITY

The dry conditions existing over the country, as a whole, are voiced by the humidity percentages, which except in a few localities, were distinctly below normal and in some instances the lowest ever recorded in August.

In portions of the upper Missouri Valley and adjacent areas in the Plateau region and also in the Great Plains and portions of the central valleys the monthly averages ranged from 5 to 20 per cent less than normal.

SEVERE LOCAL STORMS, AUGUST, 1929

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path, yards [1]	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Hartford, Conn., and vicinity.	1				$1,000,000	Heavy hail	Heavy loss to tobacco crop and much damage to greenhouses; communication lines out of order.	Official, U. S. Weather Bureau. Hartford Courant (Conn.).
Plainfield and Hammonton, N. J.	1					Wind and hail	Trees uprooted; glass in windows broken; fruit trees injured.	Official, U. S. Weather Bureau.
Tama, Webster, Grundy, and Marshall Counties, Iowa.	1	11 p. m.			50,000	Wind	Character of damage not reported	Do.
Kossuth County, Iowa	2	1:30 a. m.	3 mi.		150,000	Tornado	Extensive damage to crops and property. Path 12 miles.	Do.
Iowa (18 counties)	2	12:01–6 a. m.				Wind	Much damage to crops, chiefly corn	Do.
Marshall County, Kans.	2	4:30 p. m.			250	Violent wind	Trees and small buildings blown down	Do.
Hay to Reparia, Wash.	2	5–6 p. m.			9,000	Hail	Standing grain damaged	Do.
Durango, Colo.	3	6:30 p. m.	2,640			Hail and wind	Considerable damage to property in mining district.	Do.
Yuma, Ariz. (10 miles south of).	3				15,000	Wind	3 small buildings demolished, many others damaged; several persons injured.	Do.
Burton, S. C.	4				3,000	Thunderstorm	A barn and contents destroyed by lightning	Do.
Las Cruces, N. Mex. (near).	6	3:30–5 p. m.				2 hail storms	Heavy damage to alfalfa and fruit	Do.
Hannibal, Mo.	6				2,000	Electrical	Church damaged by lightning	Do.
Oshkosh, Wis. (near)	9				5,000	Hail	Damage chiefly to fruit	Do.
Cheyenne, Wyo. (south of).	10	3:20 p. m.				Tornado	No details. Storm passed some distance from station, probably in near-by Colorado.	Do.
Harrison County, Iowa	10	1 p. m.				do	No damage, cloud did not touch ground	Do.
Mills, Cherokee, and Lyon Counties, Iowa.	11	P. m.				Hail and wind	Crops badly injured	Do.
Van Buren, Tama, Jefferson, and Keokuk Counties, Iowa.	12	do				do	Considerable crop damage	Do.
La Crosse, Vernon, Monroe, Columbia, Dane, and Rock Counties, Wis.	13	6:35–10 a. m.	1–5 mi.	1	900,000	do	Severe damage to corn, tobacco, greenhouses, and buildings over path 45 miles long.	Do.
Adams County, Pa. (south-central).	13	3–4 p. m.				Heavy hail and wind.	Chief damage to crops; many windows broken	Do.
Macoupin, Montgomery, and Christian Counties, Ill.	13	4 p. m.	8 mi.			Hail	Crops injured 40 to 50 per cent; greenhouses and auto tops damaged. Path 20 miles.	Do.
Stoughton, Wis. (near)	13	4:30 p. m.			2,000	do	Crops, chiefly tobacco, damaged	Do.
Newton, Ill. (near)	13	6:30 p. m.	60		300	Small tornado	No details of damage reported. Path 1 mile long.	Do.
Sumner, Altamont, Sparta, and Literberry, Ill.	13	P. m.				Wind, electrical, and hail.	Barns and buildings damaged by wind and lightning; much crop injury.	Do.
Boyertown, Pa.	13–14				100,000	3 thunderstorms	Much damage to property in Oley Valley; several buildings demolished; 2 persons injured.	Do.
Philadelphia, Pa., and vicinity.	14	2–4 p. m. 8:45 p. m. to midnight.		4	75,000	Thunderstorms and wind.	Loss chiefly to crops; other minor damage	Do.
Ferndale, Md.	14				3,500	Wind	Building unroofed and otherwise damaged	Do.
Freeport Mills, Pa. (near)	14				13,500	Electrical	3 barns and contents destroyed	Do.
Franklin, Manor and Fayette Counties, Ohio.	14				17,265	Wind and electrical.	Considerable damage to property	Do.
Stevensville, Md.	14					Elctrical	2 houses and a barn destroyed	Do.
Fort Lupton, Colo. (near)	18		1,760			Hail and electrical.	Severe storm accompanied by lightning. No details of damage.	Do.
Quakertown, Pa. (near)	18–19		1,760		7,500	Hail	Crops badly injured; trees uprooted; windows broken.	Do.
Henderson, N. C.	19		1–3 mi.		50,000	do	Corn, cotton, and tobacco ruined	Do.
Crandon, S. Dak.	21	6. p. m.			1,000	Wind and hail	A few small buildings wrecked; some damage to crops.	Do.
Oconomowoc, Wis. (near)	22				20,000	Electrical	Considerable damage by lightning	Do.
Providence, R. I.	23	10:32–11:45 p. m.				Thunderstorm	Electric service disrupted; 500 telephones out of order; 4 buildings struck by lightning.	Do.
Homestead, Pa.	23	P. m.			10,000	Electrical	Power plant damaged; several buildings struck by lightning.	Do.
Ottawa, Ill.	23				50,000	do	Several buildings burned	Do.
Saline County, Ill. (northern).					3,000	do	Several buildings damaged	Do.
Portage, Ohio	23–24					do	3 barns and 1 building destroyed; several houses struck by lightning.	Do.
Groton, S. Dak. (near)	24	4:30 p. m.			25,000	Wind and hail	Buildings destroyed or damaged; cattle killed	Do.
Rock Hill, S. C.	24					Hail	Considerable crop damage	Do.
Atchison County, Kans.	25	6:30 p. m.			600	Small tornado	Freight house and filling station damaged	Do.
Clarke County, Iowa	25	6 a. m.				Hail and wind	Much corn blown down	Do.
Vineland, Kans. (near)	25		3 mi.		50,000	Heavy hail	Extensive injury to corn crop over a 3-mile path.	Do.
Harrisburg, Pa.	27	1:52–4:10 p. m.			10,000	Electrical	Farm property destroyed	Do.
Buena Vista, Colo.	27	5:30–8 p. m.	880–1,320		5,000	Rain and hail	Entire crop of grain, hay, lettuce, and peas was completely destroyed.	Do.
Hampshire County, W. Va.	27		1,760		15,000	Hail	Crops injured	Do.
Harrisburg, Ill. (near)	27				6,000	Electrical	Several buildings damaged; livestock killed	Do.
Groveton, Tex. (near)	28	2:40 p. m.				Wind	Corn and cotton blown down; 2 farm homes unroofed; several barns and outbuildings wrecked.	Do.
Woodruff, S. C.	29	4. p. m.	1,460–7,040		200,000	Hail	Heavy damage to crops and property over path 8 miles long.	Do.

[1] Mi. signifies miles instead of yards.

RIVERS AND FLOODS

By R. E. SPENCER

The only rises of consequence during August were a few widely scattered flash floods, which occurred between the 6th and 14th in Colorado, Arizona, and New Mexico as results of heavy local summer-time rains.

On the 6th, according to newspaper reports, a dam across Virgin River near Littlefield, Ariz., was destroyed, with a considerable loss of livestock below; and at about the same time in Fremont, Otero, and Huerfano Counties of Colorado at least five bridges were destroyed, considerable damage was done to highways and crops, and the town of Walsenburg suffered some loss in tangible property. The newspaper estimate of these latter losses is $75,000. Reports were received, also, of damage to the extent of about $4,000 in the vicinity of Higbee, Colo. (Purgatoire River), and of $1,375 in the vicinity of Fort Lyon, Colo. (Arkansas River), about the 7th. A saving of $1,000 worth of property was effected at Fort Lyon through flood warnings.

A considerable rise—the result of torrential rainfall over the tributary drainage of the Puerco River—occurred in the Rio Grande at San Marcial, N. Mex., following the 9th. The crest, 5.5 feet, was the highest of record at that station. In spite of strenuous efforts to protect the levee at San Marcial, at least three breaks occurred in it, with the result that most of the town was flooded. No lives were lost, women and children having been removed to another city before serious inundation occurred. The damage in San Marcial and vicinity was estimated at $50,000, in addition to which the villages of San Acacia and San Antonio, N. Mex., suffered considerable losses. Press reports state that at least 30,000 acres were overflowed between Socorro and San Marcial.

[All dates in August except as otherwise specified]

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	State	Date
ATLANTIC DRAINAGE					
Santee:	*Feet*			*Feet*	
Rimini, S. C.	12	1	3	12.2	2, 3.
Ferguson, S. C.	12	3	5	12.3	4, 5.
EAST GULF DRAINAGE					
Etowah: Canton, Ga.	11	(1)	1	15.8	July 31.
MISSISSIPPI DRAINAGE					
Arkansas:					
Fort Lyon, Colo.	6			8.5	7.
Lamar, Colo.	8			8.8	8.
Great Bend, Kans.	5			5.3	10, 11.
Purgatoire: Higbee, Colo.	4.5			10.0	7.
Canadian: Logan, N. Mex.	4			6.0	8, 10.
WEST GULF DRAINAGE					
Rio Grande: San Marcial, N. Mex.	2			5.5	12.
PACIFIC DRAINAGE					
Colorado: Parker, Ariz.	7	(1)	(2)	11.9	June 2.

[1] Continued from last month. [2] Continued at end of month.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, AUGUST, 1929

By J. B. KINCER

General summary.—The outstanding important feature of the weather of the month was the continued drought which prevailed over practically all interior sections, including the Northwest and many Rocky Mountain districts; at the close of the month conditions were still serious in most areas.

During the first decade there were beneficial showers in parts of the Ohio Valley, the middle Appalachian region, and locally elsewhere, but there was a serious deficiency of precipitation over the Northeast and the Northwest, especially the latter area where hot weather prevailed, intensifying the dryness. Moisture was ample from Kentucky southward and in parts of the Southwest and the southern Rocky Mountain area, but west of the Rockies there was practically no rainfall.

During the second decade there were sufficient rains in only a few rather restricted areas east of the Rocky Mountains, mainly in parts of the Middle Atlantic States and New England, but in much of the Lake region and generally over the section between the Mississippi River and the Rockies serious drought prevailed. Parts of the Southeast still had sufficient moisture, while conditions were favorable, due to previous rains, over southern Rocky Mountain sections, but most of the Pacific Northwest continued seriously dry.

During the last decade there was no appreciable improvement in the agricultural situation, with a general rain needed throughout the Ohio Valley and widespread, serious drought continuing in most of the States between the Rockies and the Mississippi River. Most late crops deteriorated, especially on uplands, while the ground was too hard and dry to plow in most sections. Timely and generous rains were very beneficial in the Appalachian region, while moisture conditions were still rather satisfactory in the southern Rocky Mountain area.

Small grains.—During the first decade harvesting and threshing winter wheat had been mostly completed in practically all parts of the eastern Ohio Valley, and to southern Iowa and Nebraska in the West. In the spring wheat sections rapid advance of harvesting, threshing, and combining was possible, with gathering of oats largely completed. There was some scattered threshing in the Ohio Valley during the second decade, but this work had been largely completed in the winter wheat area, except in the West, where it was well along. Harvest and threshing were also favored in the spring wheat region, with generally excellent harvest weather. During the last decade the weather favored late harvesting in the spring wheat area with cutting nearly done in most parts and threshing well along. Plowing was retarded generally due to hard, dry soil, although much had been accomplished in the eastern and lower Ohio Valley and north to Kansas in the West. The weather favored rice harvest, but flax suffered from lack of rain in the Dakotas.

Corn.—During the first decade corn made good progress in the Ohio Valley, where timely rains were beneficial, but the crop was still uneven in places. In Iowa progress was poor in the south and west where it was too dry, but fair elsewhere, with the bulk of the crop in milk and roasting-ear stages. In southern Missouri and Kansas and locally in Nebraska and South Dakota rains were favorable, but in much of the Southwest it was too dry for corn and much deterioration occurred. During the second decade conditions remained substantially unchanged, with a general need of rain in the western belt and severe suffering in some places, although in Iowa and Missouri the droughty conditions were mitigated somewhat by cool weather. During the last decade there was practically no relief from the dry conditions. Corn made fair progress in the eastern Ohio Valley, but in western parts there were complaints of firing and deterioration. The bulk of the crop was maturing too rapidly in Iowa and elsewhere west of the Mississippi River

much suffering from the drought was reported, with rapid maturity; 50 to 75 per cent of the crop in Kansas was reported to have passed the stage where rain could benefit.

Cotton.—During the first decade cotton made mostly good progress in the Carolinas and Georgia, except that it was too wet in parts and too dry in other sections. Advance varied considerably in the central parts of the belt, ranging from deterioration to very good, and in some southern districts blooming was reported as practically ceased and plants shedding badly. Conditions were unfavorable in Louisiana, but in Arkansas progress was good to excellent. Advance was fairly good in Oklahoma, but rain was needed, while in Texas progress was mostly poor, except in the northwest; heat and drought caused premature opening and some shedding. During the second decade conditions continued generally favorable in the Carolinas, but it was too wet in parts of Florida and Georgia, while in Alabama and Mississippi progress ranged from deterioration to good. Growth was slow in Louisiana and fruiting much diminished; unfavorable droughty conditions continued in western Arkansas, but elsewhere in that State advance ranged from fair to excellent. Growth was rather poor in Oklahoma due to need of rain, while in Texas cotton mostly deteriorated, with heat and drought causing premature opening and shedding. During the last decade conditions remained generally unchanged east of the Mississippi River and in Louisiana and Arkansas. Progress of cotton was good in parts of the extreme West and the Panhandle of Texas, but elsewhere rather general deterioration continued, with plants opening prematurely and shedding. Deterioration continued in Oklahoma, with further complaints of shedding, blooming nearly stopped, and bolls small and opening prematurely.

Miscellaneous crops.—Meadows, pastures, and ranges were rather seriously in need of rain at the close of the month, due to the continued drought, and especially so in the Northwest where there were reports of water holes drying and livestock being shipped out. Livestock held up well generally, however, although there were some reports of feeding dairy stock locally. Haying was favored throughout the month, with much saved.

Truck crops also needed rains generally, with moisture urgent in places to save the late potato crop. Setting some winter truck had begun in Florida at the close of the month. Tobacco cutting advanced in Kentucky, although at the end of the month cutting was being forced in the Burley area. Mostly excellent weather for sugarcane prevailed in Louisiana and sugar beets did well throughout the month. Citrus were favored generally.

WEATHER OF THE ATLANTIC AND PACIFIC OCEANS

NORTH ATLANTIC OCEAN

By F. A. YOUNG

August was another unusually quiet month over the North Atlantic, and up to time of writing only 15 vessels have forwarded storm reports, while only 3 of these reported winds as high as force 9.

As shown in Table 1, there were no unusually large pressure departures at any of the land stations given. The North Atlantic HIGH was well developed during the first half of the month, as also was the Icelandic LOW during the greater part of the first decade.

Fog was again very prevalent, being reported on from 5 to 10 days off the American coast, north of the Virginia Capes; on 9 to 17 days over the Grand Banks, and on from 7 to 12 days over the middle and eastern sections of the steamer lanes.

Charts VIII to XI cover the period from the 1st to 4th and Charts XII to XV from the 7th to 10th. These charts are presented to give an idea of the weather encountered by the airship *Graf Zeppelin* during the flights from Germany to the United States and return.

On the 1st and 2d an area of low pressure was over the Province of Quebec and another off the coast of Great Britain, although both were accompanied by moderate weather only. On the 3d the eastern disturbance was central near Stornoway, Scotland, and on that day moderate gales were reported by vessels in the westerly and southerly quadrants. By the 4th the western LOW was central near Halifax, and the New York Weather Bureau station reported a NW. wind, force 8.

From the 5th to 18th, judging from reports received, there ensued a period of remarkably favorable weather, with an area of high pressure over a large section of the ocean during the greater part of the period, although one vessel encountered a moderate gale on the 5th, as shown in table.

On the 19th a moderate disturbance was central near 58° N., 18° W., that moved but slightly during the next three days, and westerly to southwesterly winds were reported from the 19th to 22d by vessels north of the 50th parallel and east of the 25th meridian.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, 8 a. m. (seventy-fifth meridian). North Atlantic Ocean, August, 1929*

Stations	Average pressure	Departure	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland	[1] 29.87	([2])	30.16	29th	29.56	19th.
Belle Isle, Newfoundland	29.86	[3] −0.03	30.08	11th [4]	29.52	6th.
Halifax, Nova Scotia	30.01	[3] −0.04	30.18	9th [4]	29.72	2d.
Nantucket	29.98	[3] −0.04	30.26	17th [4]	29.46	4th.
Hatteras	29.99	[3] −0.05	30.28	21st	29.70	4th.
Key West	29.99	[3] −0.03	30.04	2d [4]	29.86	28th.
New Orleans	30.01	[3] −0.01	30.12	17th [4]	29.90	13th. [4]
Cape Gracias, Nicaragua	29.89	[3] 0.00	29.94	8th	29.84	14th. [4]
Turks Island	30.06	[3] +0.32	30.10	2d [4]	30.00	24th.
Bermuda	30.17	[3] +0.03	30.30	17th	30.04	12th.
Horta, Azores	30.20	[3] +0.04	30.42	5th	29.94	18th.
Lerwick, Shetland Islands	29.75	[3] −0.05	30.12	26th	29.41	4th.
Valencia, Ireland	29.98	[3] +0.06	30.28	18th	29.54	31st.
London	30.00	[3] +0.02	30.28	19th	29.50	1st.

[1] Average of 28 observations.
[2] No normal available.
[3] From normals shown on Hydrographic Office Pilot Chart, based on observations at Greenwich mean noon, or 7 a. m., seventy-fifth meridian time.
[4] And on other date or dates.
[5] From normals based on 8 a. m. observations.

On the 19th a tropical disturbance of limited extent and intensity was central near St. Lucia in the Windward Islands. This moved slowly westward, apparently causing but little damage, and on the 22d was central some distance northwest of Grand Cayman Island. No reports of heavy weather have been received from any vessels within the limits of this disturbance.

On the 26th a fairly well-developed disturbance was central near 56° N., 25° W., and one vessel in the westerly quadrant experienced a northerly wind, force 9.

On the 31st Halifax was near the center of a LOW of limited extent, and on the same date a second depression was central near 48° N., 25° W., while moderate gales were reported near the centers of both.

According to a special report received, severe storms occurred in the vicinity of the Black Sea on the 27th and 31st, respectively.

Waterspout.—American steamship *Excellency*, Capt. C. D. Hermanson; observer, R. Lindquist, second mate. Gibraltar to New York:

On August 2d at 6:10 p. m. (9:15 p. m., G. C. T.) observed a small waterspout in 41° 31′ N., 40° 50′ W. Barometer 30.34 inches. Temperature of air 78°. Atmosphere clear. Wind WSW., 3. Clouds cu.-nb. 3. The waterspout did not appear to reach the level of the sea, but there was a marked disturbance on the surface. As the clouds were moving rapidly, cloud and waterspout disappeared over the horizon in about five minutes after the latter was sighted.

OCEAN GALES AND STORMS, AUGUST, 1929

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				*Inches*					
Saco, Am. S. S.	Rotterdam	New York	29 61 N.	50 00 W.	Aug. 3	4 a., 4	Aug. 4	29.55	SW	W., 6	NW	NW., 9	SW.-W.-NW.
West Zeda, Am. S. S.	Galveston	Rotterdam	39 30 N.	60 00 W.	4	5 p., 4	5	29.78	SSW	SSW., 8	SW	SSW., 8	Steady.
Balsam, Am. S. S.	New York	Glasgow	40 55 N.	54 08 W.	5	Noon, 5	5	29.98	S	S., 7	S	S., 8	Do.
Sarcoxie, Am. S. S.	Havre	New York	49 43 N.	13 46 W.	6	Noon, 6	6	29.81	NW	NW., 6	N	N., 8	Do.
Inkum, Br. S. S.	North Shields	do	58 13 N.	17 13 W.	18	8 a., 19	20	29.77	WSW	WSW., —	W	—, 8	WSW.-WNW.
City of Flint, Am. S. S.	Hull	Philadelphia	56 45 N.	27 54 W.	21	8 a., 22	22	29.55	W	W., 8	WNW	—, 8	W.-WNW.
Yselhaven, Du. S. S.	Emden	New York	58 49 N.	16 55 W.	21	10 a., 22	23	29.39	WSW	WSW., 8	W	WSW., 8	Steady.
Cameronia, Br. S. S.	Glasgow	do	54 39 N.	25 06 W.	26	8 p., 26	27	29.43	W	W., 3	N	NW., 8	W.-NW.
Albatross II, U. S. S.	Nantucket	Bermuda	37 24 N.	66 37 W.	28	Noon, 28	28	29.89	SW	SW., 8	WSW	SW., 8	SW.-WSW.
Exchange, Am. S. S.	Gibraltar	Boston	42 55 N.	46 21 W.	29	5 p., 29	29	29.91	SSW	SSW., 8	W	SSW., 8	Steady.
West Loquassuck, Am. S. S.	Port Said	New York	38 33 N.	68 48 W.	30	Noon, 30	30	29.81	NE	NE., 8	NNE	NE., 8	Do.
Gloxinia, Br. S. S.	Philadelphia	Hamburg	46 54 N.	29 00 W.	30	8 a., 31	31	29.47	S	E., 7	NNE	E., 8	
Examelia, Am. S. S.	Seville	New York	40 50 N.	60 31 W.	31	Noon, 31	Sept. 1	29.81	S	SW., —	W	—, 9	
Anacortes, Am. S. S.	Hull	Philadelphia	49 30 N.	48 48 W.	31	11 p., 31	1	29.96	SW	—, 9	SE	—, 9	SE.-SW.
Exchange, Am. S. S.	Gibraltar	Boston	42 50 N.	56 10 W.	31	11 a., 31	1	29.69	SW	SW., 7	WNW	W., 8	SW.-WNW.
NORTH PACIFIC OCEAN													
Mobile City, Am. S. S.	San Pedro	Balboa	20 34 N.	107 05 W.	Aug. 2	4 a., 3	Aug. 3	29.77	ESE	ESE., 7	SE	ESE., 8	ESE.-SE.
Do	do	do	17 10 N.	101 28 W.	5	8 a., 5	5		SE	SE., 8	ESE	ESE., 8	ESE.-SE.
Sylvan Arrow, Am. S. S.	do	do	18 06 N.	103 58 W.	2	6 a., 2	3	29.78	E	E., 8	SE	E., 8	2 pts.
Tongking, Dan. M. S.	San Francisco	do	18 43 N.	103 34 W.	2	4 a., 2	4	29.76	E	E., 5	S	E., 8	E.-S.
Ontariolite, Can. M. S.	Talara, Peru	Vancouver	18 26 N.	106 24 W.	5	—, 6	6	28.80	N	WNW., 12	S	WNW., 12	WNW.-SW.
Admiral Peoples, Am. S. S.	San Francisco	Portland	40 08 N.	124 23 W.	9	Noon, 9	9	29.84	NW	NW., 9	N	NW., 9	Steady.
Admiral Watson, Am. S. S.	Seattle	Kodiak	56 26 N.	132 36 W.	16	3 p., 16	17	29.88	SE	SE., 8	SE	SE., 9	Do.
Wisconsin, Am. S. S.	Portland	Shanghai	49 20 N.	170 46 E.	18	2 a., 18	19	29.44	S	S., 7	S	S., 8	S.-SSE.
Golden Hind, Am. S. S.	San Francisco	do	31 07 N.	172 13 E.	21	—, 21	23	29.29	ENE	ESE., 9	S	SSE., 10	ENE.-ESE.
New York, Am. S. S.	Hong Kong	San Francisco	45 06 N.	170 35 E.	25	Mdt., 25	26	29.12	SSE	SSE., —	SW	ESE., 10	ESE.-SSW.
Tatsuno Maru, Jap. S. S.	San Francisco	Balboa	17 15 N.	101 40 W.	29	4 p., 29	30	29.80	ENE	E., 8	E	E., 9	E.-SSW.
Chickasaw City, Am. S. S.	Los Angeles	do	17 24 N.	101 53 W.	29	10 a., 29	30	29.70	E	E., 6	E	E., 8	E.-ESE.
Moerdijk, Du. S. S.	Colon	Los Angeles	18 08 N.	104 14 W.	29	8 a., 30	30	29.42	ESE	NW., 9	NE	NE., 9	Backing.
Canadian Miller, Can. S. S.	Victoria	Balboa	18 22 N.	104 00 W.	30	10 a., 30	30	29.60	E	ESE., 9	SW	ESE., 9	ESE.-S.
Tsuyama Maru, Jap. S. S.	Balboa	Los Angeles	17 20 N.	101 30 W.	29	4 a., 30	31	29.72	SSE	SE., 8	E	SSE., 9	
Hampstead, Br. S. S.	Vladivostok	Puget Sound	48 49 N.	174 00 E.	28	2 p., 30	31	29.13	E	N., 5	NE	N., 8	N.-NE.
SOUTH PACIFIC OCEAN													
Maunganui, Br. S. S.	Sydney	San Francisco	21 10 S.	159 50 W.	17	6 p., 17	19	29.92	SE	E., 9	SSE	E., 9	E.-SE.
SOUTH ATLANTIC OCEAN													
Chincha, Am. S. S.	Delagoa Bay	Rio de Janeiro	29 12 S.	16 10 W.	9	1 a., 9	11	29.78	WSW	WSW., 11	SSW	WSW., 11	WSW.-SSW.

NORTH PACIFIC OCEAN

By WILLIS E. HURD

During August the California-Pacific anticyclone extended abnormally far into higher latitudes, and on the average for the month embraced even the eastern part of the Aleutian Islands area, the pressure at Dutch Harbor showing the extraordinarily high figure of 30.04 inches. On several days, however, cyclones of moderate intensity crossed the upper Pacific, or fluctuated over the Gulf of Alaska and neighboring coast waters of Canada and the United States.

The average center of the Aleutian cyclone which was very shallow, as in July, lay in the vicinity of Kodiak.

Barometric data for several island and coast stations in west longitudes, including Point Barrow in the Arctic Ocean, are given in the following table:

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level at indicated hours, North Pacific Ocean and adjacent waters, August, 1929*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Point Barrow [1]	29.89		30.30	22d	29.42	10th.
Dutch Harbor [1 2]	30.04	+0.14	30.48	22d	29.60	2d.
St. Paul [1]	29.93	+0.17	30.48	22d	29.38	26th.
Kodiak [1]	29.88	+0.03	30.16	29th	29.42	18th.
Midway Island [1 3]	30.09	0.00	30.18	8th	29.88	28th.
Honolulu [4]	29.99	−0.01	30.10	2d	29.88	31st.
Juneau [4]	29.93	−0.09	30.25	1st	29.40	21st.
Tatoosh Island [4 5]	30.06	+0.05	30.29	19th	29.84	1st.
San Francisco [4 5]	29.96	+0.02	30.08	18th	29.78	13th.
San Diego [4 5]	29.90	+0.01	30.03	11th	29.75	31st.

[1] P. m. observations only.
[2] For 27 days.
[3] For 30 days.
[4] A. m. and p. m. observations.
[5] Corrected to 24-hour mean.

Very few days with gales seem to have occurred along the upper steamship routes. In American waters the only gale of consequence was that of the 9th when a strong northwesterly wind which attained force 9 occurred off the upper coast of California. In Alaskan waters a gale of similar force blew off the coast south of Sitka. No other gales were reported in west longitudes. In east longitudes gales were more frequent, occurring in higher latitudes along the route between Japan and the western Aleutians on the 16th to 18th, the 25th and 26th, and on the 29th. Those of the 25th and 26th attained the force of a whole gale in connection with a comparatively deep cyclone central near 45° N., 170° E.

In middle latitude routes a cyclone of some depth occurred west of the one hundred and eightieth meridian on the 21st and 22d, the American steamship *Golden Hind* encountering whole southeasterly gales on those dates near 31° N., 172° E.

Two typhoons, one of great severity, occurred in Asiatic waters. Their histories are given in the subjoined article prepared by the Rev. José Coronas, S. J., chief of the meteorological division of the Philippine Weather Bureau. At the close of the month, also, another typhoon, of intensity yet undetermined from reports at hand, was central in the western part of the China Sea.

Two tropical disturbances occurred in Mexican west coast waters this month. The first was in the process of formation as early, at least, as August 2, when fresh southeasterly to easterly gales, though with little depression of the barometer, were encountered from Cape Corrientes southward to a point west-southwest of Acapulco. On the 4th and 5th further gales from some easterly direction were encountered off Acapulco and near the western entrance to the Gulf of Tehuantepec. The lowest pressure given in these several instances was 29.72 inches, with a fresh gale from east-northeast, reported by the Danish motorship *Tongking*, in 15° N., 98° 05′ W. The principal and determining report as to the severe nature of this storm came from the Canadian tanker *Ontariolite*, Capt. James Brown, observer John White, Talara, Peru, to Vancouver. This vessel entered the storm area with moderate northerly gales at 3 p. m. of the 5th, position not given, but south of the eighteenth parallel. At midnight she had a strong gale from northwest with heavy southeast swell and torrential rains. The wind rose to a storm from northwest, barometer 29.40, at 5 a. m. of the 6th, and increased to a hurricane, with precipitous seas, at about 7 a. m., lowest pressure 28.80 inches, in position estimated by the observer at 18° 26′ N., 106° 24′ W. By 9 o'clock the wind had changed to southwest, 10, and the barometer had risen to 29.64, with the hurricane rapidly passing north of the *Ontariolite*. By noon the gale had diminished to force 7, direction south by west, and pressure had risen to 29.80. No later report of the storm has been received.

The second cyclone occurred in the same general vicinity from the 28th to the end of the month, and was experienced by several vessels, reports of which appear in the table of gales and storms. This disturbance was first observed as a storm near 16° N., 98° to 100° W., on the 28th, but observations from the steamship *Santa Eulalia* on the 29th indicate unsettled weather, with depressed barometer near 15° N., 109° W., showing that cyclonic conditions were spread over a considerable area. On the 30th gales of reported force 9 occurred from Acapulco to Cape Corrientes. Mr. A. Larsen, third officer of the steamship *Absaroka*, reported of this date that "at 11.30 a. m. the barometer had dropped to 29.64 while nearing the coast south of Cape Corrientes. The wind suddenly shifted to west, force 9, and the northerly sea was terrific. The swell from southeast caused the water to boil and churn, throwing up clouds of water." The lowest observed pressure was 29.42 inches, observed on board the Dutch steamship *Moerdijk* at 8 a. m. of the 30th, in 18° 08′ N., 104° 14′ W. The observer on the *Santa Eulalia* said that "according to reports from Mexican stations this storm later passed over the southern end of Lower California."

Another cyclonic disturbance in the southeastern Pacific is indicated by a further report from the *Santa Eulalia*, the vessel encountering rough, unsettled weather, depressed barometer, shifting winds, and high, confused seas on the 21st and 22d near 20° N., 135° to 139° W.

The prevailing direction of the wind at Honolulu in August was from the east, with a maximum velocity of 22 miles an hour from the east on the 3d. The average velocity for the month was the lowest on record since 1905.

Fog continued frequent between the fortieth and fifty-fifth parallels, especially west of longitude 160° W. About 50 per cent of the days were foggy over a considerable area south of the Aleutian Islands, the occurrence thence diminishing slowly toward northern Japan and rapidly toward the American continent. Along the American coast, however, the percentage rose rapidly, especially off California, along the central coast line of which fog was observed on at least 17 days.

It was during August that the first nonstop flight ever made across the Pacific Ocean was accomplished by the German airship *Graf Zeppelin*. The airship left Kasumagaura Airport, Tokyo, Japan, at 2:13 a. m., August 23, eastern daylight time, and was sighted outside San Francisco Bay at 10.02 p. m. of the 25th. The actual flying time from shore to shore was about 68 hours and 12 minutes. The weather conditions attending the flight were as good as could be expected. A shallow low-pressure area lay east of Japan at time of leaving, but was not strong enough to cause rough conditions. Some thick weather was encountered south of the Aleutians. Owing to the presence of a persistent cyclone over the Gulf of Alaska and neighboring waters southward, the *Zeppelin*, upon advices from the United States Weather Bureau, took a more southerly course than was originally intended, her most northerly position being latitude 46° N. in longitude 161° W.

TYPHOONS AND DEPRESSIONS

ONE FORMOSA AND ONE HONG KONG TYPHOON IN AUGUST, 1929

By Rev. José Coronas, S. J.

[Weather Bureau, Manila, P. I.]

The most important typhoons that have visited the Far East during this month of August up to the 29th were one that traversed Formosa on the 11th, and one that struck Hong Kong on the 22d.

Formosa typhoon: August 7 to 18.—This typhoon, which was not so severe, but rather an ordinary typhoon, was clearly noticed on our Weather Maps of August 7 over the Pacific not far from 127° longitude E. and 19° latitude N. It moved WNW. on the 8th and NNW. from the 9th until 6 a. m. of the 12th. It passed near to the northeast of Basco in the afternoon of the 9th. The barometric minimum reported from that station was 742.9 mm. (29.25 inches) with strong winds from the west quadrants. The center of the typhoon traversed the northern part of Formosa in the morning of the 11th. On the 12th the typhoon moved to NW. or NW. by W., and then on the 13th and 14th it recurved northeastward to the southwest of Shanghai, and traversed the Yellow Sea, Korea, and the Japan Sea on the 15th to 17th.

The approximate position of the center at 6 a. m. of the 8th to 18th was as follows:

August 8, 6 a. m. 126° 00′ longitude E., 19° 00′ latitude N.
August 9, 6 a. m. 123° 05′ longitude E., 20° 25′ latitude N.
August 10, 6 a. m. 122° 05′ longitude E., 22° 10′ latitude N.
August 11, 6 a. m. 121° 30′ longitude E., 24° 10′ latitude N.
August 12, 6 a. m. 120° 30′ longitude E., 27° 00′ latitude N.
August 13, 6 a. m. 118° 55′ longitude E., 28° 10′ latitude N.
August 14, 6 a. m. 118° 20′ longitude E., 28° 45′ latitude N.
August 15, 6 a. m. 120° 00′ longitude E., 31° 10′ latitude N.
August 16, 6 a. m. 123° 25′ longitude E., 34° 35′ latitude N.
August 17, 6 a. m. 126° 55′ longitude E., 38° 00′ latitude N.
August 18, 6 a. m. 140° 00′ longitude E., 43° 55′ latitude N.

Hong Kong typhoon: August 19 to 22.—This typhoon was very small in diameter, but very severe, at least while passing near Pratas and close to Hong Kong. As it was so small it is impossible at present to know whether it existed or not before the 19th. It is likewise impossible to know whether it was a well-developed typhoon when the center passed south of Basco as we have no observations made between Basco and Camiguin Island in the afternoon of the 19th. The observations of Basco together with those made on board the steamers *Pathfinder* and *Bustamante* showed clearly at 6 a. m. of the 19th that there was a small depression of typhoon center over the Pacific near the Balintang Channel to the east-southeast of Basco and northeast of Aparri. This small center entered the Balintang Channel in the afternoon of the same day moving westward. At 6 a. m. of the 20th our Weather Map showed the same small depression or typhoon over the China Sea west of Balintang Channel.

At 6 a. m. of the 21st wireless reports received from the steamer *Laomedon* confirmed the existence of a small typhoon very near 118° longitude E. and 20° latitude N. moving still westward. Suddenly after 2 p. m. the typhoon changed its direction to NNW. as it was evident from the observations of Pratas and those of the steamer *Laomedon*. But after 10 p. m. of the same day it inclined again westerly moving straight to Hong Kong with a WNW. or NW. by W. direction. The winds of Pratas backed quite rapidly from NE. to N., NW., W., SSW., and SSE. from 6 a. m. of the 21st to 6 a. m. of the 22d. The center passed very few miles to the south of Hong Kong at about 1.30 p. m. of the 22d. The barometric minimum recorded there was 735.1 mm. (28.94 inches) and the hurricane winds from the east quadrants acquired the maximum velocity of 120 miles per hour. It is considered as the worst typhoon experienced in Hong Kong during the last six years.

The approximate position of the center during the period August 19 to 22 was as follows:

August 19, 6 a. m. 123° 35′ longitude E., 19° 50′ latitude N.
August 19, 2 p. m. 122° 40′ longitude E., 19° 50′ latitude N.
August 20, 6 a. m. 119° 35′ longitude E., 19° 50′ latitude N.
August 20, 2 p. m. 118° 30′ longitude E., 19° 50′ latitude N.
August 21, 6 a. m. 118° 25′ longitude E., 19° 50′ latitude N.
August 21, 2 p. m. 117° 30′ longitude E., 20° 00′ latitude N.
August 21, 10 p. m. 116° 50′ longitude E., 21° 20′ latitude N.
August 22, 6 a. m. 115° 25′ longitude E., 22° 00′ latitude N.
August 22, 2 p. m. 114° 00′ longitude E., 22° 20′ latitude N.

CLIMATOLOGICAL TABLES [1]

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature amd precipitation by sections, August, 1929

Section	Temperature							Precipitation					
			Monthly extremes							Greatest monthly		Least monthly	
	Section average	Departure from the normal	Station	Highest	Date	Station	Lowest	Date	Section average	Departure from the normal	Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	80.2	+0.6	Madison	102	3	Scottsboro	50	30	2.10	−2.44	Dothan	7.07	Union Springs	0.02
Arizona	79.6	0.0	Parker	115	[2] 29	Alpine	38	20	2.74	+0.41	Baboquivari	7.52	Mohawk	0.18
Arkansas	80.8	+1.1	Booneville	110	6	Dutton	41	15	1.29	−2.40	St. Francis	4.73	3 stations	0.00
California	73.9	+1.8	Greenland Ranch	122	12	Sierraville	25	26	0.10	0.00	Aguanga	4.70	251 stations	0.00
Colorado	66.4	+1.6	Rocky Ford	106	17	Pearl	28	23	3.17	+1.08	Victor	10.95	Rifle	0.11
Florida	81.4	0.0	2 stations	99	[2] 6	2 stations	58	[2] 16	6.40	−0.69	Penny Farms	11.78	Indiantown	1.76
Georgia	80.2	+0.8	Talbotton	102	3	Blue Ridge	48	[2] 5	3.24	−1.98	Thomasville	11.68	Hartwell	0.13
Idaho	70.3	+3.7	Orofino	110	27	3 stations	28	[2] 5	0.37	−0.26	Obsidian	2.01	3 stations	0.00
Illinois	72.3	−1.9	2 stations	100	22	2 stations	42	15	2.51	−0.95	Flora	6.41	Paris	0.59
Indiana	71.2	−2.1	Rome	101	1	do	39	[2] 16	2.75	−0.56	Winona Lake	6.25	Terre Haute	0.45
Iowa	71.9	+0.2	Keokuk (No. 2)	102	22	Decorah	37	15	2.44	−1.00	Toledo	9.27	Guthrie Center	0.78
Kansas	78.9	+1.5	2 stations	110	[2] 2	Oketo	44	15	2.14	−0.95	Salina	7.99	Oswego	0.41
Kentucky	74.0	−1.6	do	100	[2] 15	Farmers	37	18	2.06	−1.67	Uniontown	5.84	St. John	0.31
Louisiana	82.1	+0.4	Dodson	105	21	Robeline	53	16	3.30	−1.89	Delta Farms	7.86	Logansport	0.00
Maryland-Delaware	71.5	−1.8	Frederick, Md	99	1	Oakland, Md	35	[2] 20	2.70	−1.57	Grantsville, Md	5.13	Woodstock, Md	1.18
Michigan	64.9	−1.6	2 stations	95	[2] 2	2 stations	29	[2] 7	1.28	−1.54	Black Lake Forest	3.86	Grand Ledge	0.12
Minnesota	68.2	+1.5	Beardsley	104	24	Meadowlands	28	15	1.98	−1.32	Wasecа	4.75	Fergus Falls	0.50
Mississippi	80.4	−0.1	4 stations	102	[2] 3	Utica	50	[2] 16	2.24	−2.07	Pearlington	6.64	Scott	0.07
Missouri	76.0	0.0	Lamonte	105	1	2 stations	43	15	2.50	−1.25	Campbell	8.57	Neosho	0.32
Montana	69.3	+4.8	Big Timber	107	14	do	24	[2] 20	0.34	−0.82	Hebgen Dam	1.31	3 stations	0.00
Nebraska	75.7	+2.9	Merriman	110	24	do	34	[2] 4	1.48	−1.33	North Platte	6.17	Lebanon	0.07
Nevada	74.1	+3.2	Las Vegas	111	[2] 2	Rye Patch	31	27	0.68	+0.29	Sharp	5.07	4 stations	0.00
New England	65.0	−1.8	3 stations	94	[2] 1	Garfield, Vt	30	30	2.68	−1.23	Hyannis, Mass	7.13	Hiram, Me	0.95
New Jersey	69.8	−2.0	Belvedere	97	1	Charlotteburg	39	21	2.58	−2.21	Plainfield	4.86	Sandy Hook	0.88
New Mexico	69.2	−0.5	Nara Visa (near)	105	3	Therma	25	[2] 15	3.57	+1.09	Des Moines	9.62	Lake Avalon	0.18
New York	65.1	−2.2	2 stations	96	26	2 stations	32	20	2.85	−0.92	High Market	8.43	Addison	0.42
North Carolina	74.7	−0.9	7 stations	97	[2] 2	Banners Elk	36	5	4.05	−1.46	Southport	10.51	Bryson City	0.74
North Dakota	68.5	+3.1	Maddock	106	31	Steele	26	14	0.77	−1.51	Stanton	2.06	Portal	T.
Ohio	68.0	−3.6	3 stations	95	[2] 2	Canfield	36	20	2.79	−0.59	McConnelsville	7.34	Ellsworth	0.71
Oklahoma	83.6	+2.5	Jefferson	112	5	Smithville	44	15	0.78	−2.21	Miami	3.68	3 stations	0.00
Oregon	67.9	+2.1	Waldo	109	10	Fremont	22	22	0.14	−0.36	Union	1.52	34 stations	0.00
Pennsylvania	67.7	−2.3	2 stations	98	1	Gouldsboro	31	20	2.52	−1.71	Phoenixville	7.20	Lloyd	0.20
South Carolina	78.0	−0.9	do	101	[2] 2	Hogback Mountain	50	4	3.18	−2.65	Ferguson	8.70	Landrum	0.60
South Dakota	73.6	+3.6	Hopewell	110	15	Pollock	32	14	1.30	−1.01	Rochford	3.72	Dupree	0.03
Tennessee	75.7	−0.7	Covington	101	3	2 stations	43	[2] 30	2.40	−1.64	Kenton	6.73	Rock Island	0.12
Texas	84.1	+1.4	Cleburne	112	4	Alpine	51	17	0.87	−1.69	Romero	6.62	34 stations	0.00
Utah	71.7	+1.8	St. George	108	[2] 13	Woodruff	35	[2] 14	1.53	+0.43	Hole-in-the-Rock Ranger Station.	5.38	Riverdale	0.08
Virginia	72.4	−1.2	Winchester	99	1	Burkes Garden	37	31	2.65	−2.02	Clarksville	8.43	2 stations	0.98
Washington	67.6	+1.7	Wahluke	108	11	Stockdill Ranch	29	25	0.41	−0.53	Mount Baker Lodge	2.45	14 stations	0.00
West Virginia	69.1	−2.9	Moorefield	101	14	Bayard	33	31	3.31	−0.66	Sutton	5.75	Wardensville	0.14
Wisconsin	66.6	−0.3	High Falls	99	31	Prentice	30	15	1.87	−1.42	Wausau	3.66	Milwaukee	0.35
Wyoming	67.8	+3.9	2 stations	103	[2] 15	Moran	24	14	0.98	−0.12	Lyman	5.90	Pavillion	0.00
Alaska (July)	55.6	−1.0	Wonder Lake	85	12	Fort Yukon	25	29	3.64	+0.90	Ketchikan	10.90	White Mountain	0.25
Hawaii	76.1	+1.3	3 stations	94	[2] 7	Volcano Observatory.	54	[2] 5	5.43	−1.15	Puohakamoa	25.89	Lahaina	0.26
Porto Rico	78.6	−0.3	Canovanas	95	1	Jayuya	59	12	9.81	+2.62	Maricao	25.25	Santa Isabel	2.42

[1] For description of tables and charts, see REVIEW, January, 1929, p. 36.

[2] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, August, 1929*

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	° *F.*	° *F.*	°*F.*		°*F.*	° *F.*		°*F.*	° *F.*	° *F.*	° *F.*	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
New England							**65.9**	**−1.5**										**76**	**2.80**	**−0.8**										**5.0**		
Eastport	76	67	85	29.84	29.92	−0.04	60.1	−0.6	76	26	68	49	1	53	22	55	52	79	2.13	−0.9	9	5,366	s.	26	s.	24	4	11	16	6.9	0.0	0.0
Greenville, Me	1,070	6	----	28.78	29.94	------	61.2	------	81	10	70	43	8	52	31	----	----	----	3.52	------	12	5,905	nw.	29	------	----	5	4	13	14	----	0.0	0.0
Portland, Me	103	82	117	29.85	29.97	−.01	64.8	−1.6	81	25	73	52	21	56	26	58	54	73	4.28	+1.1	9	5,326	sw.	24	nw.	4	14	11	6	4.3	0.0	0.0
Concord	289	70	79	29.65	29.95	−.03	64.6	−2.2	88	12	77	41	21	53	38	----	----	----	3.00	−0.5	9	3,231	nw.	21	w.	4	13	12	6	4.5	0.0	0.0
Burlington	403	11	48	29.52	29.95	−.02	63.6	−4.3	85	26	73	45	30	54	31	----	----	----	1.54	−1.8	9	5,246	s.	22	s.	14	7	13	11	6.0	0.0	0.0
Northfield	876	12	60	29.04	29.98	.00	59.9	−3.5	83	26	72	37	21	48	38	56	54	84	1.79	−1.7	10	3,552	s.	25	s.	14	1	16	14	7.1	0.0	0.0
Boston	125	115	188	29.83	29.96	−.03	69.3	−0.6	90	1	78	54	21	60	27	61	57	70	2.22	−1.4	6	5,179	sw.	23	w.	4	12	10	9	5.2	0.0	0.0
Nantucket	12	14	90	29.96	29.97	−.02	67.3	−0.5	81	26	74	57	28	61	21	62	60	83	3.18	−0.2	8	8,843	sw.	34	se.	3	17	9	5	4.3	0.0	0.0
Block Island	26	11	46	29.94	29.97	−.02	67.9	−0.6	80	26	74	56	20	62	17	63	61	82	1.28	−2.4	8	8,593	s.	35	se.	11	16	9	6	4.2	0.0	0.0
Providence	160	215	251	29.80	29.97	−.02	69.0	−2.0	87	1	78	53	21	60	26	62	57	71	2.44	−1.1	10	6,691	nw.	40	nw.	4	16	7	8	4.3	0.0	0.0
Hartford	159	122	----	29.81	29.98	−.01	69.2	+0.3	90	12	79	50	21	59	32	----	----	----	4.82	+0.5	8	------	sw.	----	----	----	10	12	9	5.0	0.0	0.0
New Haven	106	74	153	29.87	29.98	−.01	69.2	−1.1	85	27	78	51	21	61	24	62	58	69	4.17	−0.1	7	5,466	n.	24	nw.	4	17	10	4	3.7	0.0	0.0
Middle Atlantic States							**71.6**	**−1.7**										**70**	**2.44**	**−1.9**										**4.7**		
Albany	97	107	115	29.87	29.97	−.01	68.6	−2.2	88	26	79	48	21	58	31	60	55	66	1.02	−2.7	7	4,306	s.	20	sw.	5	18	9	4	3.5	0.0	0.0
Binghamton	871	10	84	29.08	30.00	+.01	66.0	−2.0	90	26	78	43	8	54	38	----	----	----	1.64	−2.0	7	2,998	nw.	17	nw.	4	13	11	7	4.7	0.0	0.0
New York	314	414	454	29.65	29.98	−.02	71.2	−1.9	88	12	79	56	5	63	21	62	57	67	1.45	−2.9	9	9,251	s.	47	nw.	1	9	14	8	5.0	0.0	0.0
Bellefonte	1,050	5	36	28.92	30.01	------	65.3	------	90	10	81	36	20	50	45	59	54	69	1.22	------	7	------	w.	----	----	----	10	14	7	5.1	0.0	0.0
Harrisburg	374	94	104	29.62	30.01	.00	71.2	−1.4	93	1	81	50	31	61	34	61	56	64	2.49	−1.6	8	3,622	n.	25	nw.	4	11	12	8	4.6	0.0	0.0
Philadelphia	114	123	367	29.88	30.00	.00	73.2	−1.6	92	12	82	59	5	65	22	63	58	63	3.22	−1.4	9	7,925	n.	40	nw.	4	9	13	9	5.0	0.0	0.0
Reading	325	81	98	29.66	30.00	------	71.2	------	95	1	82	53	21	61	29	62	57	64	3.41	−0.8	10	3,565	n.	25	se.	14	14	10	7	4.5	0.0	0.0
Scranton	805	111	119	29.16	30.01	+.01	67.3	−2.5	89	1	79	44	31	56	38	59	54	67	3.29	−0.4	7	4,162	sw.	32	nw.	11	12	13	6	4.4	0.0	0.0
Atlantic City	52	37	172	29.94	29.99	−.01	71.2	−1.3	87	24	78	56	31	65	25	65	62	76	2.42	−2.1	7	9,022	s.	35	s.	3	12	13	6	4.4	0.0	0.0
Cape May	17	13	49	----	----	------	71.4	−2.0	86	12	79	55	31	64	24	66	64	81	1.86	------	6	------	s.	----	----	----	11	13	7	----	0.0	0.0
Sandy Hook	22	10	55	29.95	29.97	------	71.2	------	86	12	78	59	5	64	21	64	61	75	0.88	−4.1	8	8,263	s.	38	nw.	4	11	11	9	4.9	0.0	0.0
Trenton	190	159	183	29.78	29.98	------	70.8	------	93	12	81	55	31	61	27	63	58	68	2.64	−2.1	9	5,858	n.	34	nw.	4	10	11	10	5.1	0.0	0.0
Baltimore	123	100	215	29.87	29.99	−.02	74.4	−1.1	94	1	83	57	31	66	28	65	59	63	4.04	−0.3	9	5,978	s.	40	se.	14	16	8	7	4.3	0.0	0.0
Washington	112	62	85	29.88	30.00	−.01	74.4	−0.6	95	13	84	54	21	65	29	65	60	67	1.30	−2.7	5	3,138	n.	22	nw.	4	13	12	6	4.9	0.0	0.0
Cape Henry	18	8	54	29.97	29.99	------	75.3	------	92	11	82	61	22	69	22	69	67	78	1.92	−2.9	8	6,620	e.	27	ne.	11	9	13	9	5.4	0.0	0.0
Lynchburg	681	153	188	29.29	30.02	.00	73.2	−2.4	93	13	83	53	31	63	31	65	62	74	3.99	+0.2	12	3,392	n.	36	nw.	24	16	10	5	4.0	0.0	0.0
Norfolk	91	170	205	29.91	30.00	.00	76.7	−0.7	91	13	84	64	22	69	20	69	66	76	2.64	−2.6	8	6,187	s.	32	n.	11	12	10	9	5.1	0.0	0.0
Richmond	144	11	52	29.86	30.00	−.01	75.1	−1.4	94	18	85	54	5	65	28	67	63	73	2.41	−2.0	10	4,028	sw.	26	nw.	29	14	13	4	4.5	0.0	0.0
Wytheville	2,304	49	55	27.70	30.02	+.01	68.2	−2.3	87	2	79	44	31	58	33	62	59	81	2.68	−1.5	9	2,799	nw.	18	w.	3	15	8	8	4.7	0.0	0.0
South Atlantic States							**78.1**	**−0.1**										**79**	**4.44**	**−1.2**										**5.3**		
Asheville	2,253	70	84	27.73	30.02	.00	70.8	+0.3	87	10	81	51	31	61	28	64	62	81	0.82	−3.3	7	3,585	nw.	24	n.	4	6	22	3	5.0	0.0	0.0
Charlotte	779	55	62	29.19	30.01	−.01	76.7	−0.4	95	14	86	59	5	67	24	68	65	75	2.78	−2.3	10	2,351	ne.	21	nw.	24	8	17	6	5.2	0.0	0.0
Greensboro	886	5	56	29.09	30.03	------	73.2	------	91	2	84	51	31	63	31	67	66	84	4.32	------	12	3,970	ne.	24	ne.	19	9	15	7	5.1	0.0	0.0
Hatteras	11	5	50	29.97	29.98	−.02	77.4	−0.6	88	2	83	62	31	72	17	72	70	81	6.48	+0.7	15	6,661	ne.	36	n.	19	10	12	9	5.4	0.0	0.0
Raleigh	376	103	110	29.61	30.00	−.01	76.2	−0.8	93	2	85	59	30	67	24	69	66	77	2.43	−3.0	10	3,619	ne.	17	nw.	4	6	16	9	5.8	0.0	0.0
Wilmington	78	81	91	29.92	30.00	.00	77.5	−0.1	94	24	86	61	31	69	24	72	70	83	7.80	+1.4	15	3,495	w.	26	w.	3	9	14	8	5.5	0.0	0.0
Charleston	48	11	92	29.95	30.00	−.01	80.7	−0.3	96	4	87	68	30	74	19	74	72	80	5.22	−1.3	10	5,790	sw.	22	e.	21	5	16	10	5.9	0.0	0.0
Columbia, S. C	351	41	57	29.63	30.01	.00	79.6	0.0	97	2	89	60	31	70	27	70	67	76	6.05	+0.6	10	3,560	ne.	26	nw.	29	14	12	5	4.2	0.0	0.0
Due west	711	10	55	29.28	30.04	------	78.2	------	96	24	89	60	31	68	29	----	----	----	0.66	------	9	4,616	sw.	29	nw.	24	13	15	3	4.0	0.0	0.0
Greenville, S. C	1,039	139	146	28.94	30.01	------	77.2	+1.4	94	2	87	60	5	68	25	68	64	71	1.35	−4.2	9	4,511	ne.	26	n.	29	10	15	6	4.8	0.0	0.0
Augusta	182	62	77	29.80	29.96	−.02	81.3	+0.9	98	24	91	63	31	71	27	72	69	74	0.90	−4.1	5	2,966	ne.	35	w.	11	7	16	8	5.5	0.0	0.0
Savannah	65	150	194	29.94	30.01	.00	80.4	−0.3	96	4	89	68	27	72	23	74	72	84	8.99	+1.7	14	5,735	w.	36	w.	4	5	12	14	6.3	0.0	0.0
Jacksonville	43	209	245	29.96	30.01	.00	80.8	−0.9	93	12	88	68	31	73	23	74	72	82	6.02	+0.2	16	5,960	sw.	36	w.	12	2	18	11	6.4	0.0	0.0
Florida Peninsula							**82.3**	**+0.2**										**77**	**6.33**	**0.0**										**5.2**		
Key West	22	10	64	29.96	29.98	.00	82.6	−0.9	92	14	88	71	17	77	16	76	74	75	6.10	+1.6	13	5,827	e.	31	w.	28	13	11	7	4.8	0.0	0.0
Miami	25	141	168	29.99	30.02	−.01	81.8	+0.4	90	14	87	71	28	76	15	75	73	75	5.51	−0.7	18	5,944	e.	26	sw.	28	7	17	7	5.7	0.0	0.0
Tampa	35	79	87	29.97	30.00	.00	82.6	+1.1	94	8	90	71	26	75	20	75	73	82	7.38	−0.8	20	3,234	ne.	20	e.	22	1	14	16	7.0	0.0	0.0
Titusville	44	5	----	29.95	30.00	------	81.2	------	98	12	90	69	21	72	25	----	----	----	4.15	------	12	------	sw.	----	----	----	18	11	2	3.3	0.0	0.0
East Gulf States							**80.6**	**+0.7**										**75**	**3.98**	**−1.3**										**4.4**		
Atlanta	1,173	190	216	28.80	30.01	.00	78.3	+1.3	94	8	88	61	16	69	25	68	63	66	1.49	−3.0	9	5,546	nw.	24	nw.	24	12	13	6	4.5	0.0	0.0
Macon	370	78	87	29.62	30.01	.00	79.8	−0.1	96	8	90	62	28	70	27	72	69	76	3.08	−1.3	9	3,261	s.	24	nw.	24	6	22	3	4.7	0.0	0.0
Thomasville	273	49	58	29.72	30.01	+.01	80.3	−0.7	94	4	90	65	29	71	24	73	72	85	11.68	+5.9	19	2,357	sw.	17	sw.	16	1	18	12	6.7	0.0	0.0
Apalachicola	36	42	49	29.96	30.00	------	80.9	------	90	13	87	70	31	75	16	76	74	80	6.78	−0.8	14	3,996	sw.	31	ne.	25	9	12	10	5.6	0.0	0.0
Pensacola	56	149	185	29.94	30.00	+.02	81.2	+0.3	93	30	86	68	16	76	17	75	73	82	5.04	−3.0	10	6,213	w.	28	ne.	4	9	15	7	5.2	0.0	0.0
Anniston	741	9	57	29.25	30.03	+.04	78.8	+2.4	95	9	91	54	16	66	36	----	----	----	0.72	−3.3	5	2,199	se.	14	nw.	24	20	10	1	2.7	0.0	0.0
Birmingham	700	11	48	29.27	30.02	+.03	80.6	+1.4	98	8	92	57	16	69	32	69	65	69	2.01	−2.2	8	2,999	n.	19	se.	21	18	11	2	3.2	0.0	0.0
Mobile	57	125	161	29.94	30.00	+.02	81.9	+0.9	93	20	90	64	16	74	26	74	72	80	6.88	0.0	12	4,432	sw.	35	ne.	12	9	13	9	5.5	0.0	0.0
Montgomery	223	100	112	29.76	30.00	+.01	81.6	+0.8	97	3	92	64	16	72	26	71	68	70	0.82	−3.4	9	3,459	sw.	31	n.	12	16	14	1	3.3	0.0	0.0
Corinth	469	6	----	----	----	------	79.4	------	101	3	92	56	16	66	39	----	----	----	3.26	------	6	------	se.	----	----	----	18	12	1	----	0.0	0.0
Meridian	375	87	95	29.61	30.00	+.02	80.4	+0.9	96	2	91	59	16	70	30	71	67	70	0.79	−3.8	5	2,744	sw.	23	e.	12	18	11	2	3.1	0.0	0.0
Vicksburg	247	65	73	29.74	30.02	+.04	80.6	−0.2	97	12	90	63	16	71	25	72	68	71	1.83	−1.6	4	3,287	n.	18	w.	11	18	10	3	2.9	0.0	0.0
New Orleans	53	76	84	29.95	30.00	+.02	83.5	+1.3	94	4	91	70	25	76	21	76	74	79	6.70	+0.9	13	2,923	ne.	22	e.	25	10	15	6	5.1	0.0	0.0
West Gulf States							**83.7**	**+1.8**										**67**	**0.73**	**−2.1**										**2.5**		
Shreveport	249	77	93	29.73	29.99	+.02	84.4	+2.4	102	12	95	64	16	74	26	72	67	62	0.50	−2.2	5	3,519	se.	31	nw.	13	28	3	0	1.5	0.0	0.0
Bentonville	1,303	11	44	28.66	29.98	+.01	79.2	+2.7	101	6	92	49	15	66	36	----	----	----	0.20	------	2	2,445	s.	16	nw.	24	30	1	0	----	0.0	0.0
Fort Smith	457	79	94	29.50	29.97	.00	83.8	+3.3	105	6	95	58	15	72	32	70	64	58	0.12	−3.2	2	4,027	e.	24	e.	7	19	9	3	3.2	0.0	0.0
Little Rock	357	136	153	29.63	30.00	+.02	81.6	+1.8	102	3	93	61	16	71	27	69	64	61	1.95	−1.8	6	4,591	e.	29	nw.	25	19	9	3	3.0	0.0	0.0
Austin	605	136	148	29.33	29.96	------	85.2	+1.4	100	14	96	68	31	74	27	72	66	61	0.01	−2.0	1	4,071	se.	19	se.	31	24	7	0	2.3	0.0	0.0
Brownsville	57	83	100	29.89	29.95	------	83.6	−0.3	95	15	92	73	30	76	19	75	73	79	3.29	+0.7	4	5,904	se.	25	ne.	25	17	11	3	3.6	0.0	0.0
Corpus Christi	20	11	78	29.96	29.97	+.04	83.6	+1.1	98	15	90	75	25	77	22	77	75	81	1.59	−0.7	4	6,587	e.	24	e.	31	21	7	3	2.7	0.0	0.0
Dallas	512	220	227	29.44	29.98	------	86.2	------	102	3	96	68	16	76	26	----	----	----	0.04	−2.7	2	6,183	se.	33	n.	4	31	0	0	0.9	0.0	0.0
Fort Worth	670	106	114	29.25	29.94	.00	86.8	+3.8	105	3	98	68	15	76	29	71	63	52	T.	−2.6	0	5,486	se.	18	ne.	14	25	4	2	2.5	0.0	0.0
Galveston	54	106	114	29.95	30.01	+.05	83.8	+0.8	94	14	88	74	24	79	15	76	74	77	0.94	−3.3	4	5,904	s.	19	s.	13	22	7	2	3.2	0.0	0.0
Groesbeck	461	11	56	29.52	29.99	------	83.4	------	100	12	96	64	31	71	31	----	----	----	0.13	−1.8	2	5,140	se.	31	ne.	13	23	8	0	2.2	0.0	0.0
Houston	138	292	314	29.85	29.99	------	84.0	+0.8	98	14	93	71	16	75	24	----	----	----	1.33	−2.8	9	5,949	s.	36	n.	26	16	15	0	3.4	0.0	0.0
Palestine	510	64	72	29.47	29.99	+.02	83.2	+1.4	99	12	95	64	31	72	30	71	66	65	T.	−2.2	0	3,797	s.	18	ne.	13	24	6	1	2.2	0.0	0.0
Port Arthur	34	58	66	29.95	29.99	------	83.5	------	96	14	91	72	30	76	21	76	73	79	3.65	------	7	4,259	e.	21	e.	13	25	4	2	2.2	0.0	0.0
San Antonio	693	119	132	29.24	29.95	+.02	85.1	+1.6	99	14	96	70	31	74	25	72	66	62	0.01	−2.4	1	3,973	se.	17	se.	18	18	13	0	3.1	0.0	0.0
Taylor	583	55	63	29.41	30.02	+.07	84.0	+2.3	101	13	96	67	15	72	28	----	----	----	0.27	−2.1	2	4,380	s.	28	se.	29	24	7	0	2.1	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, August, 1929*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Ohio Valley and Tennessee	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*° F.*	*° F.*	*°F*		*°F.*	*°F.*		*°F.*	*° F.*	*° F.*	*° F.*	*%*	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
							72.8	**−2.2**										**68**	**2.04**	**−1.4**										**4.2**		
Chattanooga	762	190	215	29.20	29.99	−0.01	77.8	+0.3	94	2	88	60	15	68	28	67	62	64	0.45	−3.6	1	4,396	ne.	22	nw.	10	15	15	1	3.5	0.0	0.0
Knoxville	995	102	111	28.99	30.02	+.01	75.6	−0.6	94	2	86	57	31	66	27	67	63	72	2.12	−1.8	8	3,563	ne.	22	n.	28	14	12	5	4.3	0.0	0.0
Memphis	399	76	97	29.59	30.01	+.03	78.6	−0.8	95	3	87	60	16	70	21	70	66	69	4.45	+1.1	5	3,687	e.	20	n.	9	20	9	2	2.9	0.0	0.0
Nashville	546	168	191	29.46	30.04	+.04	77.1	−0.7	95	2	87	58	15	67	32	68	63	68	0.51	−3.2	8	4,603	nw.	25	s.	6	18	10	3	3.6	0.0	0.0
Lexington	989	193	230	29.00	30.05	+.04	72.4	−2.1	93	1	82	54	15	62	29				1.49	−2.0	5	7,017	se.	38	n.	23	17	10	4	3.4	0.0	0.0
Louisville	525	188	234	29.47	30.05	+.05	75.0	−2.0	96	22	85	56	16	65	31	65	60	65	1.45	−2.0	8	5,440	n.	35	nw.	23	15	13	3	3.6	0.0	0.0
Evansville	431	76	116	29.59	30.05	+.06	75.5	−1.9	96	1	86	58	16	66	27	66	62	70	3.38	0.0	6	4,235	ne.	32	nw.	10	13	14	4	4.2	0.0	0.0
Indianapolis	822	194	230	29.16	30.04	+.04	72.4	−1.3	92	22	82	51	20	63	28	62	57	63	2.49	−0.8	6	5,624	e.	39	nw.	23	14	12	5	4.1	0.0	0.0
Royal Center	736	11	55	29.26	30.05		68.3		90	22	80	45	20	57	33				1.62	−0.9	8	4,806	s.	30	w.	13	11	12	8	4.5	0.0	0.0
Terre Haute	575	96	129	29.42	30.03		73.3		95	22	84	53	20	63	30	64	59	67	0.45	−2.8	6	4,461	n.	23	n.	2	14	11	6	4.4	0.0	0.0
Cincinnati	627	11	51	29.37	30.04	+.03	71.0	−2.6	90	13	82	50	16	60	35	62	58	69	1.80	−1.6	8	3,345	ne.	22	nw.	13	15	9	7	3.9	0.0	0.0
Columbus	822	179	222	29.18	30.05	+.04	69.5	−3.5	88	10	79	52	30	60	28	61	56	67	3.78	+0.5	7	4,899	nw.	30	nw.	13	15	11	5	4.2	0.0	0.0
Dayton	899	137	173	29.10	30.03		70.7	−2.7	88	13	81	51	20	60	34	62	57	67	1.21	−2.1	8	4,132	ne.	21	nw.	13	10	16	5	4.9	0.0	0.0
Elkins	1,947	59	67	28.04	30.05	+.03	65.3	−3.8	85	1	77	42	16	54	37	59	57	82	1.81	−2.0	7	2,385	nw.	24	nw.	27	8	11	12	6.0	0.0	0.0
Parkersburg	637	77	82	29.41	30.06	+.05	70.2	−3.7	90	1	81	49	16	60	34	61	57	70	3.87	+0.4	10	2,714	nw.	22	nw.	14	13	9	9	5.0	0.0	0.0
Pittsburgh	842	353	410	29.14	30.03	+.02	68.2	−4.7	87	10	78	51	31	59	30	60	55	66	1.79	−1.4	6	5,055	w.	27	nw.	4	12	8	11	4.9	0.0	0.0
Lower Lake Region							**67.1**	**−2.6**										**68**	**1.96**	**−1.1**										**4.7**		
Buffalo	767	247	280	29.18	30.00	+.01	65.8	−2.8	84	13	73	51	30	59	24	60	57	75	1.22	−1.9	3	8,416	sw.	36	w.	14	16	9	6	4.0	0.0	0.0
Canton	448	10	61	29.48	29.95		62.8	−5.0	83	22	73	38	30	52	32				1.81	−1.8	9	4,935	sw.	24	w.	15	14	5	12	5.1	0.0	0.0
Ithaca	836	5	100	29.11	30.00		63.6		88	10	75	41	31	52	41	58	55	74	5.27	+1.9	7	4,704	nw.	26	nw.	5	13	7	11	5.2	0.0	0.0
Oswego	335	76	91	29.62	29.98	−.01	65.2	−3.2	87	26	73	50	31	57	32	59	54	68	1.39	−1.2	8	5,163	s.	25	w.	4	14	8	9	4.5	0.0	0.0
Rochester	523	86	102	29.45	30.01	+.02	66.4	−2.8	90	22	76	48	20	57	33	58	52	65	1.31	−1.6	11	4,569	sw.	27	w.	5	16	6	9	4.5	0.0	0.0
Syracuse	596	65	79	29.36	30.00	+.01	66.2	−2.4	88	22	76	49	20	57	32				4.26	+1.4	8	4,101	s.	22	w.	4	12	9	10	5.0	0.0	0.0
Erie	714	130	166	29.26	30.02	+.01	67.4	−2.2	86	10	74	51	20	60	25	60	55	65	0.29	−3.0	3	7,334	nw.	26	nw.	3	16	10	5	3.7	0.0	0.0
Cleveland	762	267	337	29.22	30.03	+.02	68.0	−2.0	86	10	74	53	15	62	23	60	54	63	1.98	−0.8	7	7,890	n.	47	nw.	3	7	15	9	5.5	0.0	0.0
Sandusky	629	5	67	29.37	30.04	+.03	69.2	−2.6	90	11	78	51	16	60	31				1.58	−1.6	5	4,610	sw.	22	nw.	3	7	17	7	5.3	0.0	0.0
Toledo	628	208	243	29.37	30.05	+.05	69.0	−2.3	90	11	78	52	4	60	26	60	55	66	1.30	−1.6	6	6,847	sw.	29	w.	13	16	9	6	3.9	0.0	0.0
Fort Wayne	856	113	124	29.13	30.04		69.3	−1.8	88	22	79	49	16	60	27	61	57	68	2.62	−0.5	5	4,403	sw.	22	nw.	13	11	13	7	5.2	0.0	0.0
Detroit	730	218	258	29.26	30.04	+.03	69.0	−1.3	92	11	78	52	4	60	26	61	57	70	0.52	−2.3	7	5,414	sw.	21	nw.	3	14	11	6	4.8	0.0	0.0
Upper Lake Region							**65.3**	**−1.0**										**72**	**1.41**	**−1.4**										**4.8**		
Alpena	609	13	92	29.36	30.02	+.02	62.4	−1.7	92	31	73	44	16	52	33	57	53	75	2.25	−0.6	8	6,598	nw.	33	nw.	3	14	12	5	4.1	0.0	0.0
Escanaba	612	54	60	29.36	30.02	+.03	62.2	−2.1	92	31	71	44	28	53	31	58	54	78	1.87	−1.3	8	5,883	s.	32	nw.	14	14	8	9	4.4	0.0	0.0
Grand Haven	632	54	89	29.36	30.03	+.04	64.8	−2.3	80	9	74	45	16	56	27	59	55	70	0.85	−2.0	6	6,145	nw.	29	sw.	22	12	14	5	4.5	0.0	0.0
Grand Rapids	707	70	87	29.28	30.04	+.04	68.2	−1.5	88	10	79	47	16	57	34	59	53	62	0.70	−1.9	4	2,991	w.	18	nw.	14	6	13	12	6.0	0.0	0.0
Houghton	668	64	99	29.28	30.00	+.03	63.4	−0.3	88	24	73	46	19	54	29				1.14	−1.6	8	5,726	w.	31	w.	4	13	8	10	5.1	0.0	0.0
Lansing	878	6	49	29.10	30.03		65.9	−2.6	89	10	79	42	16	53	36	59	56	75	0.29	−2.5	6	2,773	w.	20	nw.	14	12	16	3	4.4	0.0	0.0
Ludington	637	60	66	29.34	30.03		63.4		80	22	70	45	28	56	21	58	55	77	0.97	−1.7	6	5,600	s.	24	s.	13	16	11	4	3.6	0.0	0.0
Marquette	734	77	111	29.21	30.01	+.03	63.4	−0.4	93	25	72	47	28	55	26	57	53	71	1.72	−1.0	8	6,612	n.	29	n.	14	8	12	11	5.7	0.0	0.0
Port Huron	638	70	120	29.34	30.03	+.03	65.9	−1.9	91	26	75	49	4	57	28	59	55	72	1.45	−1.2	5	6,438	nw.	27	w.	14	14	14	3	3.9	0.0	0.0
Sault Sainte Marie	614	11	52	29.32	30.01	+.02	61.6	−0.5	86	25	71	45	16	52	30	55	52	77	2.04	−0.6	6	5,043	nw.	35	nw.	4	14	9	8	4.6	0.0	0.0
Chicago	673	7	131	29.32	30.05	+.05	70.6	−1.0	93	22	78	54	15	63	24	62	58	71	3.49	+0.3	7	5,896	ne.	24	sw.	23	12	12	7	4.8	0.0	0.0
Green Bay	617	109	141	29.36	30.02	+.03	66.1	−1.6	89	31	76	46	15	56	27	60	56	72	1.70	−1.5	10	5,583	s.	27	nw.	13	8	12	11	5.8	0.0	0.0
Milwaukee	681	125	221	29.31	30.04	+.04	69.6	+0.4	90	25	78	50	15	62	25	61	56	68	0.35	−2.3	6	7,378	w.	29	sw.	16	13	11	7	4.6	0.0	0.0
Duluth	1,133	5	47	28.81	30.02	+.05	65.3	+2.7	90	31	76	41	15	54	30	57	53	73	0.93	−2.2	8	6,624	nw.	33	nw.	13	16	10	5	4.2	0.0	0.0
North Dakota							**69.3**	**+3.2**										**55**	**1.07**	**−1.3**										**3.6**		
Moorhead	940	50	58	28.98	29.98	+.02	69.8	+3.7	95	21	83	42	14	56	36	58	50	58	0.75	−2.1	6	4,681	s.	22	n.	13	13	11	7	4.5	0.0	0.0
Bismarck	1,674	8	57	28.21	29.96	+.02	70.6	+3.3	99	23	86	38	14	55	45	57	49	54	0.75	−1.1	4	5,012	e.	31	nw.	19	15	15	1	3.8	0.0	0.0
Devils Lake	1,478	11	44	28.43	29.98	+.04	67.1	+2.3	99	23	82	37	14	52	43	56	48	60	1.55	−0.9	7	5,241	s.	27	nw.	12	17	10	4	3.6	0.0	0.0
Ellendale	1,457	10	56	28.45	30.00		68.0		97	23	84	38	14	52	49				1.70	−1.4	10	7,166	se.	40	se.	19	14	13	4	3.9	0.0	0.0
Grand Forks	833	12	67				67.7		101	23	82	39	14	53	41	59			1.16		7		nw.		s.	24	26	4	1		0.0	0.0
Williston	1,878	41	48	28.00	29.94	+.01	69.8	+3.7	100	23	86	44	25	54	48	56	45	48	0.58	−0.9	4	3,829	se.	25	n.	24	23	7	1	2.4	0.0	0.0
Upper Mississippi Valley							**72.0**	**−0.7**										**71**	**2.20**	**−1.1**										**4.5**		
Minneapolis	918	102	208	29.02	29.99		71.0	+1.1	92	24	81	51	27	61	29				2.15	−1.0	7	6,374	s.	39	n.	11	11	13	7	4.5	0.0	0.0
St. Paul	837	236	261	29.11	30.01	+.04	70.1	+0.7	90	24	80	49	15	60	27				1.37	−1.6	7	6,309	se.	33	w.	25	14	13	4	4.2	0.0	0.0
La Crosse	714	11	48	29.26	30.02	+.04	69.4	−0.6	90	25	81	46	15	58	30	62	58	76	1.79	−1.9	8	2,189	s.	22	nw.	13	13	14	4	4.3	0.0	0.0
Madison	974	70	78	29.02	30.04	+.05	68.5	−1.3	91	22	77	49	15	60	26	61	56	70	0.87	−2.3	6	4,223	s.	22	nw.	13	13	13	5	4.4	0.0	0.0
Wausau	1,247	4	64	28.72	30.04		66.6		90	31	78	42	15	56	33				3.66	+0.1	9	3,068	s.	18	nw.	13	12	3	16	6.1	0.0	0.0
Charles City	1,015	10	51	28.97	30.03	+.06	69.4	+0.3	90	22	81	44	15	58	31	62	57	69	1.24	−2.2	4	3,360	se.	19	nw.	10	18	11	2	3.0	0.0	0.0
Davenport	606	71	79	29.38	30.03	+.05	72.4	−0.7	98	22	82	51	15	62	28	64	60	69	2.69	−0.8	4	4,428	sw.	28	w.	22	9	16	6	4.7	0.0	0.0
Des Moines	861	84	97	29.12	30.01	+.04	73.4	+0.3	95	21	84	49	15	63	32	64	60	70	2.82	−0.7	7	3,851	sw.	18	se.	2	12	12	7	4.4	0.0	0.0
Dubuque	700	81	96	29.29	30.03	+.05	70.4	−1.3	92	22	80	48	15	60	28	62	58	69	1.83	−1.4	3	3,170	s.	21	n.	13	12	11	8	4.9	0.0	0.0
Keokuk	614	64	78	29.38	30.04	+.06	73.2	−1.8	97	22	83	52	15	64	27	65	61	69	1.41	−1.8	5	3,602	s.	24	s.	2	10	12	9	5.0	0.0	0.0
Cairo	358	87	93	29.65	30.02	+.03	75.8	−2.0	96	2	85	57	15	67	25	68	65	75	3.29	+0.3	9	4,070	ne.	34	n.	13	13	9	9	4.6	0.0	0.0
Peoria	609	11	45	29.39	30.06	+.07	71.6	−0.9	95	22	82	49	15	61	30	64	60	75	3.02	−0.1	7	2,874	ne.	13	nw.	3	12	15	4	4.5	0.0	0.0
Springfield, Ill	636	154	191	29.37	30.03	+.04	72.6	−1.9	95	22	82	51	15	63	26	64	60	70	2.08	−1.1	6	6,570	s.	24	s.	21	10	14	7	4.6	0.0	0.0
Hannibal	534	74	109	29.46	30.02	+.04	74.1	−2.0	98	2	84	49	15	64	31				1.34	−2.0	10	4,193	sw.	21	e.	6	11	13	7	4.4	0.0	0.0
St. Louis	568	265	303	29.42	30.02	+.03	76.4	−0.9	99	2	85	57	15	67	24	66	62	66	3.40	+0.4	7	6,335	s.	33	sw.	13	18	9	4	3.4	0.0	0.0
Missouri Valley							**76.2**	**+2.3**										**64**	**1.85**	**−1.4**										**3.7**		
Columbia, Mo	784	6	84	29.20	30.01	+.04	76.6	+1.0	100	2	88	50	15	66	32				0.40	−3.2	6	4,109	ne.	25	sw.	13	14	12	5	4.2	0.0	0.0
Kansas City	963	161	181	28.99	29.99	+.02	78.2	+1.6	100	1	88	57	15	68	31	67	61	61	4.13	0.0	9	5,614	s.	33	sw.	24	14	13	4	3.9	0.0	0.0
St. Joseph	967	11	49	28.98	29.99		77.0		101	2	88	50	15	66	33	67	63	69	2.09	−1.4	10	4,629	se.	28	nw.	22	20	8	3	3.0	0.0	0.0
Springfield, Mo	1,324	98	104	28.65	30.03	+.06	77.0	+1.3	97	1	87	56	15	67	30	66	62	66	2.97	−1.1	6	5,658	s.	33	se.	8	25	6	0	1.9	0.0	0.0
Iola	984	11	50	28.97	29.99	+.03	79.2	+2.1	102	1	92	49	15	66	37				0.81	−2.7	7	3,166	s.	18	n.	6	14	13	4	4.0	0.0	0.0
Topeka	987	92	107				78.4	+2.2	103	2	90	53	15	67	41				2.64	−1.4	7	5,297	s.	24	ne.	3	14	13	4	3.9	0.0	0.0
Lincoln	1,189	11	81	28.74	29.97	+.02	76.7	+2.3	104	21	88	48	15	65	41	65	60	62	0.92	−2.6	6	5,462	s.	25	nw.	13	12	11	8	4.4	0.0	0.0
Omaha	1,105	115	122	28.84	29.99	+.03	75.8	+1.4	98	21	86	53	15	66	30	66	61	65	1.56	−1.5	7	4,237	s.	26	nw.	13	16	13	2	3.2	0.0	0.0
Valentine	2,598	47	54	27.33	29.99	+.05	74.6	+2.9	102	15	89	42	14	60	45	62	55	59	2.60	+0.4	10	4,896	s.	28	s.	20	19	7	5	3.7	0.0	0.0
Sioux City	1,135	94	164	28.81	29.99	+.04	73.8	+1.8	94	21	85	48	15	63	33	64	59	65	1.55	−1.6	10	6,504	se.	38	n.	11	15	13	3	4.0	0.0	0.0
Huron	1,306	59	74	28.62	29.99	+.04	73.0	+3.6	99	24	87	42	14	59	43	61	55	61	1.99	−0.5	10	5,613	se.	35	n.	21	17	12	2	3.6	0.0	0.0
Pierre	1,572	70	75				77.6	+4.8	108	15	92	44	14	63	50				0.68	−1.4	4										0.0	0.0
Yankton	1,233	49	57	28.68	29.97	+.02	74.1	+2.1	97	24	86	47	14	62	39				1.68	−1.3	8	3,865	se.	22	n.	24	12	15	4	4.3	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, August, 1929*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	° F.	° F.	°F.		°F.	°F.		°F.	° F.	° F.	° F.	%	In.	In.		Miles								0–10	In.	In.
Northern Slope							71.4	+5.0										50	1.23	0.0										3.5		
Billings	3,140	5					72.2		103	14	92	45	14	52	58				0.23		5		nw.				21	6	4		0.0	0.0
Havre	2,505	11	44	27.36	29.94	+0.03	71.6	+6.2	99	14	89	41	20	54	49	55	42	42	0.26	−1.0	5	3,592	e.	28	w.	10	18	13	0	2.8	0.0	0.0
Helena	4,110	87	112	25.85	29.94	.00	72.2	+7.2	99	14	87	49	20	57	43	54	41	40	0.11	−0.7	2	4,906	sw.	29	sw.	18	18	11	2	3.0	0.0	0.0
Kalispell	2,973	48	56	26.93	29.91	−.02	67.9	+5.1	94	30	84	39	20	52	44	52	38	40	0.14	−0.7	2	3,994	nw.	25	w.	19	23	8	0	2.3	0.0	0.0
Miles City	2,371	48	55	27.47	29.96	+.03	75.8	+4.3	100	14	91	52	3	61	42	58	46	42	0.28	−0.8	6	3,278	s.	24	nw.	12	18	11	2	3.0	0.0	0.0
Rapid City	3,259	50	58	26.67	30.00	+.07	73.1	+3.6	103	15	87	49	14	59	48	59	50	50	1.29	−0.4	7	4,489	w.	25	n.	6	17	12	2	3.5	0.0	0.0
Cheyenne	6,088	84	101	24.17	30.00	+.08	68.4	+2.8	90	15	80	49	14	56	35	55	48	56	1.80	+0.2	10	6,198	s.	34	sw.	19	10	13	8	5.1	0.0	0.0
Lander	5,372	60	68	24.76	29.98	+.06	71.5	+6.0	95	14	87	48	8	56	43	55	46	49	0.28	−0.2	4	3,313	sw.	29	nw.	19	10	17	4	4.5	0.0	0.0
Sheridan	3,790	10	47	26.15	29.98		70.6		99	14	89	43	14	52	56	57	49	58	0.63	−0.3	3	2,441	s.	17	se.	25	18	13	0	3.2	0.0	0.0
Yellowstone Park	6,241	11	48	24.04	30.02	+.09	64.8	+3.9	87	14	80	42	10	50	43	50	40	51	1.37	+0.3	8	4,658	sw.	36	sw.	26	13	12	6	4.0	0.0	0.0
North Platte	2,821	11	51	27.11	29.97	+.03	77.0	+6.2	101	16	91	50	14	64	41	64	58	62	6.17	+3.8	8	3,701	se.	20	n.	16	18	9	4	3.6	0.0	0.0
Middle Slope							78.3	+2.4										57	1.82	−0.9										3.6		
Denver	5,292	106	113	24.87	30.02	+.10	73.0	+2.3	93	15	84	55	6	62	31	58	51	53	2.72	+1.3	4	4,321	s.	24	ne.	28	12	16	3	4.2	0.0	0.0
Pueblo	4,685	80	86	25.37	29.96	+.05	74.4	+1.7	96	15	87	56	12	62	37	60	53	56	4.44	+2.6	11	3,852	nw.	26	sw.	21	13	14	4	4.3	0.0	0.0
Concordia	1,392	50	58	28.55	29.99	+.04	78.2	+1.7	103	21	90	53	15	67	34	66	61	62	1.33	−1.6	8	4,280	s.	24	ne.	6	10	12	9	4.8	0.0	0.0
Dodge City	2,509	11	51	27.46	30.00	+.07	79.2	+1.5	102	5	92	57	14	66	38	65	58	60	1.58	−1.1	9	5,264	se.	30	ne.	31	20	5	6	3.1	0.0	0.0
Wichita	1,358	139	158	28.57	29.96	+.01	80.7	+2.4	105	5	92	60	15	69	38	67	60	58	1.30	−1.8	4	7,053	s.	27	s.	21	16	11	4	3.5	0.0	0.0
Broken Arrow	765	11	56	29.18	30.00		81.2		102	6	94	56	15	69	34				0.43	−3.4	3	6,872	s.	23	n.	9	19	11	1	3.1	0.0	0.0
Oklahoma City	1,214	10	47	28.72	29.96	+.02	84.4	+4.7	106	6	97	62	29	72	31	68	61	54	0.93	−2.0	2	5,227	s.	19	n.	11	25	5	1	2.0	0.0	0.0
Southern Slope							82.3	+2.7										52	1.36	−0.9										2.6		
Abilene	1,738	10	52	28.19	29.94	+.02	86.4	+4.4	103	5	99	67	15	74	32	67	56	43	0.05	−2.2	1	5,129	s.	19	e.	4	22	8	1	2.6	0.0	0.0
Amarillo	3,676	10	49	26.36	29.99	+.07	79.2	+3.5	98	5	92	63	9	67	33	64	56	55	4.54	+1.5	12	4,565	sw.	24	ne.	3	20	8	3	3.0	0.0	0.0
Del Rio	944	64	71	28.95	29.91	+.01	86.2	+2.0	100	13	96	71	30	76	26	71	64	53	T.	−1.7	0	5,633	se.	25	e.	14	26	5	0	1.7	0.0	0.0
Roswell	3,566	75	85	26.43	29.96	+.08	77.4	+0.8	95	6	90	59	17	64	36	63	55	55	0.85	−1.3	7	3,650	se.	29	sw.	22	20	8	3	3.1	0.0	0.0
Southern Plateau							78.6	+1.2										58	1.56	+0.5										4.0		
El Paso	3,778	152	175	26.23	29.92	+.08	79.0	−0.2	95	2	90	62	12	68	26	63	55	51	1.18	−0.5	15	5,042	e.	31	se.	14	14	16	1	3.6	0.0	0.0
Santa Fe	7,013	38	53	23.43	29.98	+.09	66.8	−0.6	82	17	78	53	6	56	28	56	51	68	3.84	+1.6	15	3,072	e.	19	ne.	26	6	18	7	5.8	0.0	0.0
Flagstaff	6,907	10	59	23.51	29.94	+.10	63.8	+1.0	82	29	77	46	19	51	34	54		73	3.03		17	4,254	nw.	32	nw.	8	1	21	9		0.0	0.0
Phoenix	1,108	10	107	28.70	29.81	+.02	89.6	+1.1	108	15	102	73	4	77	32	71	62	47	2.09	+1.1	11	3,465	w.	33	e.	22	17	11	3	3.7	0.0	0.0
Yuma	141	9	54	29.66	29.80	+.04	91.9	+1.5	113	30	105	73	17	79	32	75	68	51	0.69	+0.2	7	2,785	sw.	28	nw.	30	16	15	0	2.8	0.0	0.0
Independence	3,957	6	27	26.00	29.94	+.13	80.2	+4.1	102	12	96	56	26	64	40	57			T.	−0.1	0		s.				18	10	3		0.0	0.0
Middle Plateau							74.2	+3.1										41	0.81	+0.1										3.2		
Reno	4,532	74	81	25.51	29.91	+.07	73.5	+6.5	102	13	91	48	5	56	42	53	37	33	0.53	+0.3	2	4,646	w.	24	w.	15	24	7	0	1.8	0.0	0.0
Tonopah	6,090	12	20				73.6		92	13	84	56	5	63	25	55	41	36	1.70		4		se.								0.0	0.0
Winnemucca	4,344	18	56	25.65	29.95	+.07	73.2	+3.9	102	13	93	43	26	54	50	52	36	31	0.06	−0.1	1	3,710	sw.	29	nw.	16	20	11	0	2.6	0.0	0.0
Modena	5,473	10	43	24.71	29.94	+.08	70.7	+1.5	93	13	85	52	6	56	40	57	48	56	2.06	+0.8	15	5,324	w.	34	nw.	15	11	16	4	4.6	0.0	0.0
Salt Lake City	4,360	163	203	25.67	29.95	+.03	77.0	+2.5	98	14	88	61	25	66	33	61	52	46	0.41	−0.4	8	4,531	s.	35	ne.	24	20	9	2	3.2	0.0	0.0
Grand Junction	4,602	60	68	25.46	29.98	+.08	76.4	+1.0	95	13	89	59	10	64	32	59	49	45	0.99	−0.2	6	3,651	se.	25	s.	28	14	13	4	3.7	0.0	0.0
Northern Plateau							74.8	+4.9										36	0.29	−0.2										2.5		
Baker	3,471	48	53	26.48	29.99	+.04	69.4	+4.8	97	11	88	43	20	51	45	53	40	39	0.25	−0.2	2	3,686	se.	18	nw.	23	21	6	4	2.3	0.0	0.0
Boise	2,739	78	86	27.14	29.92	−.01	77.2	+5.4	103	14	93	52	24	61	42	57	42	34	0.11	−0.1	2	2,870	se.	20	ne.	25	19	11	1	2.5	0.0	0.0
Lewiston	757	40	48	29.14	29.93	−.02	77.5	+4.7	104	30	95	50	20	60	46				0.20	−0.4	2	2,265	e.	25	nw.	23	20	10	1	2.4	0.0	0.0
Pocatello	4,477	60	68	25.54	29.94	+.02	74.2	+4.6	98	14	89	49	11	60	43	56	43	41	1.11	+0.4	7	5,193	se.	45	sw.	14	12	15	4	4.2	0.0	0.0
Spokane	1,929	101	110	27.94	29.99	+.04	73.0	+4.9	99	28	89	44	20	57	44	55	40	35	0.06	−0.6	2	3,569	s.	23	sw.	23	24	6	1	1.8	0.0	0.0
Walla Walla	991	57	65	28.88	29.93	−.03	77.6	+4.9	101	2	92	51	24	64	36	57	40	31	0.03	−0.5	1	2,872	s.	16	w.	23	26	5	0	1.6	0.0	0.0
North Pacific Coast Region							63.8	+1.5										66	0.48	−0.3										3.6		
North Head	211	11	56	29.87	30.09	+0.6	58.8	+1.2	71	27	62	50	17	55	12	57	56	91	0.80	−0.2	6	8,635	n.	31	s.	31	13	9	9	4.8	0.0	0.0
Port Angeles	29	8	53	30.05	30.08		59.0		83	10	68	45	24	50	33				0.27	−0.4	5	4,303	sw.	22	w.	14	15	9	7	4.0	0.0	0.0
Seattle	125	215	250	29.91	30.04	+.04	64.8	+1.7	84	27	74	49	24	55	29	57	51	66	1.13	+0.4	5	4,278	nw.	20	sw.	21	16	10	5	3.6	0.0	0.0
Tacoma	194	172	201	29.85	30.05	+.03	64.9	+2.3	84	28	75	46	24	55	27				0.37	−0.4	4	4,396	n.	20	n.	10	11	17	3	4.6	0.0	0.0
Tatoosh Island	86	9	53	29.90	30.06	+.06	56.8	+1.5	69	27	61	48	10	52	19	56	55	95	1.02	−1.0	7	5,814	s.	27	s.	2	4	11	16	7.0	0.0	0.0
Yakima	1,076	58	67	28.81	29.94		74.6		100	1	90	45	24	59	38	56	42	38	T.	−0.2	0	3,722	nw.	20	nw.	18	26	4	1	1.5	0.0	0.0
Medford	1,425	4	80	28.47	29.94		70.6		102	10	91	45	27	50	52	57	49	54	0.00		0		nw.	19	nw.	2	28	3	0	0.8	0.0	0.0
Portland, Oreg.	153	68	106	29.88	30.03	+.02	69.1	+2.4	95	10	81	50	24	57	31	59	53	61	0.23	−0.4	2	3,388	nw.	14	s.	23	16	9	6	3.9	0.0	0.0
Roseburg	510	75	99	29.47	30.02	+.02	68.1	+0.1	98	10	84	46	20	52	41	57	49	58	0.01	−0.3	1	2,743	n.	18	nw.	14	24	5	2	1.8	0.0	0.0
Middle Pacific Coast Region							68.4	+1.5										64	T.	0.0										2.5		
Eureka	62	73	89	30.00	30.07	+.07	57.8	+1.8	70	27	63	50	25	53	20	55	53	86	0.01	−0.2	1	3,356	nw.	16	nw.	14	7	16	8	5.4	0.0	0.0
Red Bluff	330	54	58	29.53	29.87	+.01	80.6	+0.9	112	10	99	53	26	62	43	59	42	32	0.00	0.0	0	3,071	s.	15	nw.	9	29	2	0	0.5	0.0	0.0
Sacramento	69	106	117	29.81	29.88	+.03	75.1	+2.2	106	13	92	50	26	58	44	60	50	53	0.00	0.0	0	5,497	s.	17	s.	11	31	0	0	0.5	0.0	0.0
San Francisco	155	208	243	29.79	29.96	+.04	61.1	+2.0	77	19	67	52	7	55	22	56	54	84	0.00	0.0	0	5,872	w.	32	w.	22	13	18	0	4.1	0.0	0.0
San Jose	141	12	110	29.82	29.97		67.2	+0.5	94	13	80	47	26	54	41				0.00	0.0	0	3,809	nw.	17	nw.	23	27	4	0	1.9	0.0	0.0
South Pacific Coast Region							76.6	+3.1										58	T.	0.0										2.1		
Fresno	327	89	98	29.53	29.87	+.05	82.0	+1.3	105	13	99	56	26	65	38	61	45	32	T.	0.0	0	4,680	nw.	18	nw.	22	29	2	0	0.6	0.0	0.0
Los Angeles	338	159	191	29.55	29.91	+.03	75.8	+4.7	96	31	86	59	1	66	23	64	58	62	0.00	0.0	0	3,039	sw.	13	w.	15	24	7	0	2.1	0.0	0.0
San Diego	87	62	70	29.80	29.90	+.01	72.0	+3.3	83	31	77	62	11	67	16	66	64	80	0.00	0.0	0	3,992	nw.	18	w.	29	14	15	2	3.6	0.0	0.0
West Indies																																
San Juan, P. R.	82	9	54	29.89	29.98		79.8	−0.7	88	12	84	72	20	75	14				7.53	+0.1	26	8,741	e.	30	e.	19	1	27	3	5.5	0.0	0.0
Panama Canal																																
Balboa Heights	118	7	97	[1]29.74	[2]29.83	.00	79.6	−1.6	91	20	86	68	12	73	19			[2]88	11.96	+3.8	22	4,359	nw.	27	ne.	23	0	3	28	8.6	0.0	0.0
Cristobal	38	7	97	[1]29.81	[2]29.84	−.01	81.0	+0.8	89	28	86	72	12	76	15	76	75	[2]84	23.78	+8.4	28	5,485	w.	25	s.	23	0	7	24	8.4	0.0	0.0
Alaska																																
Juneau	80	11	50	[1]29.84	[1]29.93		56.1		85	3	63	43	31	49	37	52	49	82	5.08		17	3,958	se.	22	nw.	6	6	4	21	7.2	0.0	0.0
Hawaiian Islands																																
Honolulu	38	86	100	[1]29.95	[1]29.99		79.0		88	28	84	71	30	74	13	71	67	70	1.98	+0.7	19	5,629	e.	22	e.	3	9	18	4	4.7	0.0	0.0

[1] Pressure not reduced to mean of 24 hours.

[2] Observations taken bihourly.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, August, 1929*

Stations	Altitude above mean sea level Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*Inches*	*Inches*	*Inch*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*Inches*	*Inches*	*Inches*
Cape Race, N. F	99				58.8		66.1	51.5	71	47	3.62		0.0
Sydney, C. B. I	48	29.90	29.95	0.00	64.8	+1.5	73.8	55.9	81	49	3.14	−0.48	0.0
Halifax, N. S	88	29.86	29.96	.00	62.6	−1.0	71.9	53.3	82	46	3.99	−0.36	0.0
Yarmouth, N. S	65	29.83	29.90	−.07	60.6	+0.4	68.1	53.2	80	47	4.27	+0.65	0.0
Charlottetown, P. E. I	38	29.83	29.87	−.07	63.8	−0.5	71.9	55.8	81	40	1.82	−1.92	0.0
Chatham, N. B	28	29.77	29.80	−.13	63.2	0.0	74.0	52.4	84	40	3.33	−0.71	0.0
Father Point, Que	20												
Quebec, Que	296	29.60	29.92	−.01	61.8	−1.3	69.7	53.9	80	44	4.90	+1.07	0.0
Doucet, Que	1,236				55.2		66.8	43.7	80	28	4.23		0.0
Montreal, Que	187	29.72	29.92	−.03	64.7	−1.7	73.1	56.4	84	49	3.38	−0.19	0.0
Ottawa, Ont	236	29.69	29.95	−.01	64.5	−0.3	75.2	53.8	88	43	3.00	−0.03	0.0
Kingston, Ont	285	29.67	29.98	.00	64.8	−2.2	72.2	57.4	80	49	2.85	+0.47	0.0
Toronto, Ont	379	29.59	29.98	−.01	65.4	−0.6	75.5	55.3	88	49	1.94	−0.82	0.0
Cochrane, Ont	930				57.8		67.9	47.7	87	40	2.59		0.0
White River, Ont	1,244	28.67	29.97	+.01	55.2	−1.2	69.6	40.8	84	30	2.31	−0.99	0.0
London, Ont	808				65.6		78.8	52.4	94	41	1.69		0.0
Southampton, Ont	656	29.30	30.01	+.02	61.3	−2.5	70.7	51.8	84	39	0.99	−1.26	0.0
Parry Sound, Ont	688	29.31	29.99	+.01	62.7	−0.8	72.1	53.3	83	45	1.72	−1.00	0.0
Port Arthur, Ont	644	29.30	30.01	+.05	60.7	+1.2	71.0	50.4	88	41	1.49	−1.26	0.0
Winnipeg, Man	760												
Minnedosa, Man	1,690	29.18	29.96	+.02	63.7	+4.3	79.4	48.0	96	34	0.27	−1.83	0.0
Le Pas, Man	860				62.5		74.8	50.2	88	36	1.69		0.0
Qu'Appelle, Sask	2,115												
Moose Jaw, Sask	1,759				68.7		85.8	51.6	102	42	0.44		0.0
Swift Current, Sask	2,392												
Medicine Hat, Alb	2,144												
Calgary, Alb	3,428												
Banff, Alb	4,521												
Prince Albert, Sask	1,450	28.41	29.96	+.04	63.3	+4.4	76.7	50.0	90	41	1.54	−0.61	0.0
Battleford, Sask	1,592												
Edmonton, Alb	2,150												
Kamloops, B. C	1,262												
Victoria, B. C	230	29.78	30.03	+.02	60.1	+1.4	68.1	52.2	84	48	0.26	−0.34	0.0
Barkerville, B. C	4,180												
Estevan Point, B. C	20												
Prince Rupert, B. C	170												
Hamilton, Ber	151												
LATE REPORTS, JULY, 1929													
Cape Race, N. F	99				55.2		63.6	46.9	77	39	2.50		0.0
Sydney, C. B. I	48	29.89	29.94	+.01	65.3	+3.0	76.4	54.2	86	45	3.02	−0.63	0.0
Halifax, N. S	88	29.89	29.99	+.03	65.0	+1.6	75.7	54.3	85	45	1.94	−2.11	0.0
Yarmouth, N. S	65	29.87	29.94	−.01	60.7	+1.2	68.4	53.0	74	44	1.59	−1.88	0.0
Charlottetown, P. E. I	38	29.82	29.86	−.04	66.0	+1.9	74.0	58.0	82	49	2.35	−1.14	0.0
Chatham, N. B	28	29.79	29.82	−.06	65.2	+0.2	77.4	53.0	90	38	2.32	−1.87	0.0
Montreal, Que	187	29.73	29.93	.00	69.8	+1.3	79.2	60.5	92	47	2.25	−2.04	0.0
Winnipeg, Man	760	29.09	29.90	−.03	68.1	+2.1	80.1	56.1	96	42	1.10	−1.98	0.0
Medicine Hat, Alb	2,144	27.60	29.80	−.10	72.9	+5.1	89.3	56.5	102	50	0.64	−1.45	0.0
Calgary, Alb	3,428	26.40	29.89	−.01	63.4	+2.8	80.5	46.4	93	35	1.30	−1.38	0.0
Banff, Alb	4,521	25.42	29.91	+.01	58.5	+1.9	75.1	41.9	88	30	0.56	−2.68	0.0
Edmonton, Alb	2,150	27.59	29.83	−.07	61.8	+1.2	75.7	47.9	88	38	3.79	+0.76	0.0
Kamloops, B. C	1,262	28.67	29.93	−.01	67.8	−0.7	80.8	54.9	96	46	0.63	−0.98	0.0
Estevan Point, B. C	20				55.4		62.0	48.9	68	40	7.29		0.0
Prince Rupert, B. C	170				55.0		60.9	49.1	69	46	6.19		0.0
Hamilton, Ber	151	30.10	30.26	+.12	80.0	+1.3	86.4	73.6	90	69	3.62	−0.82	0.0

Chart I. Departure (°F.) of the Mean Temperature from the Normal, August, 1929

Shaded portions show excess (+).
Unshaded portions show deficiency (—).
Lines show amount of excess or deficiency.
Statute Miles
Bermuda
Havana
Cienfuegos
Santiago de Cuba
Key West
Tampa
Charleston
Jacksonville
Savannah
Miami
Nassau
Hatteras
Norfolk
Cape Henry
Cape May
Atlantic City
Block Island
Portland
Eastport
Father Point
Anticosti
Quebec
Montreal
Ottawa
Toronto
Kingston
Port Arthur
Duluth
Minneapolis
Winnipeg
Swift Current
Medicine Hat
Calgary
Edmonton
Prince Albert
Battleford
Qu'Appelle
Moosejaw
Regina
Prince Rupert
Barkerville 5 a.m.
4 a.m.
9 a.m.
8 a.m.
7 a.m.
6 a.m.
+2°
+4°
+6°
+2°
+4°
+2°
+2°
+2

Chart II. Tracks of Centers of Anticyclones, August, 1929. (Inset) **Departure of Monthly Mean Pressure from Normal**

(Plotted by Arthur J. Haidle)

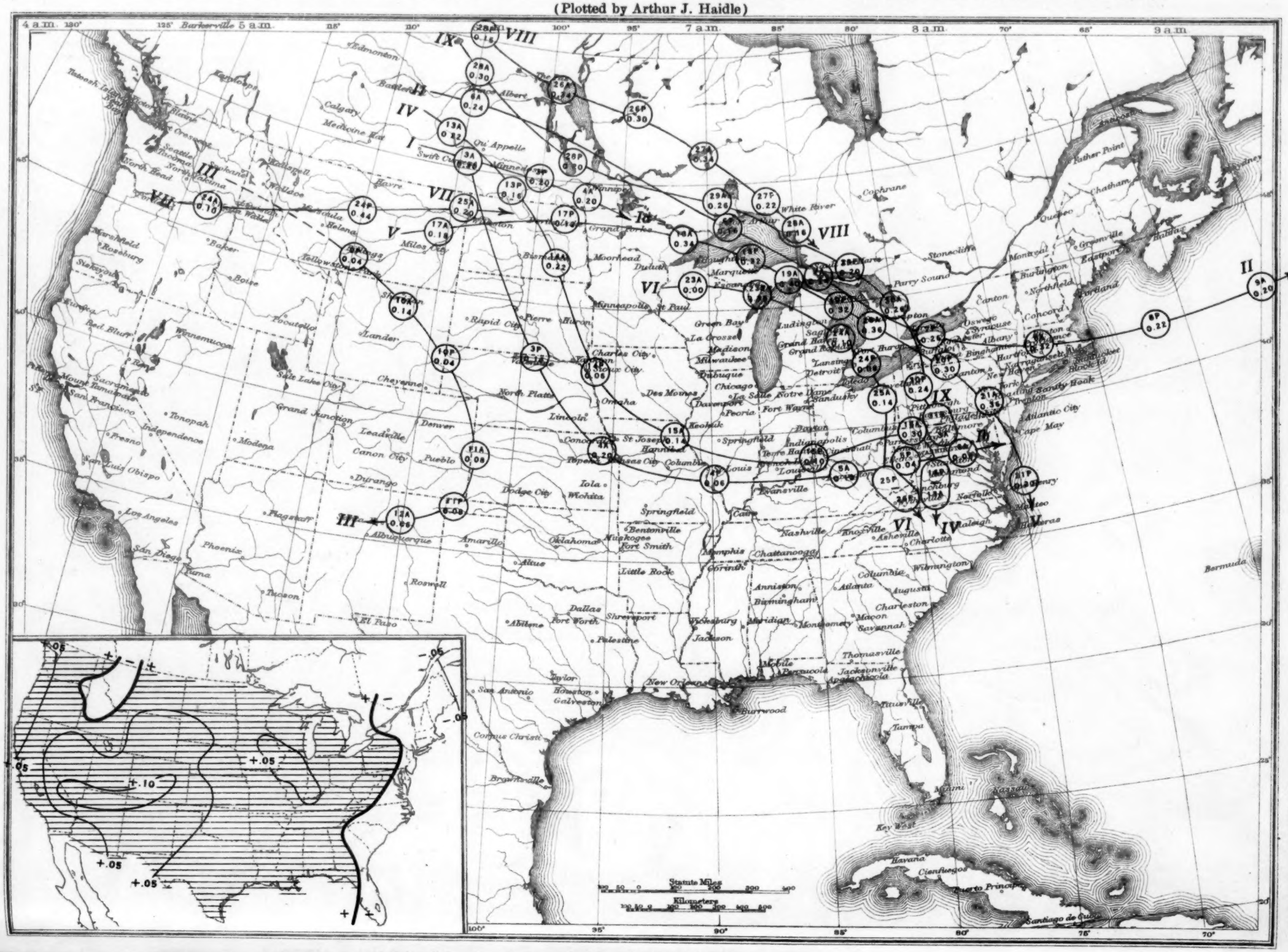
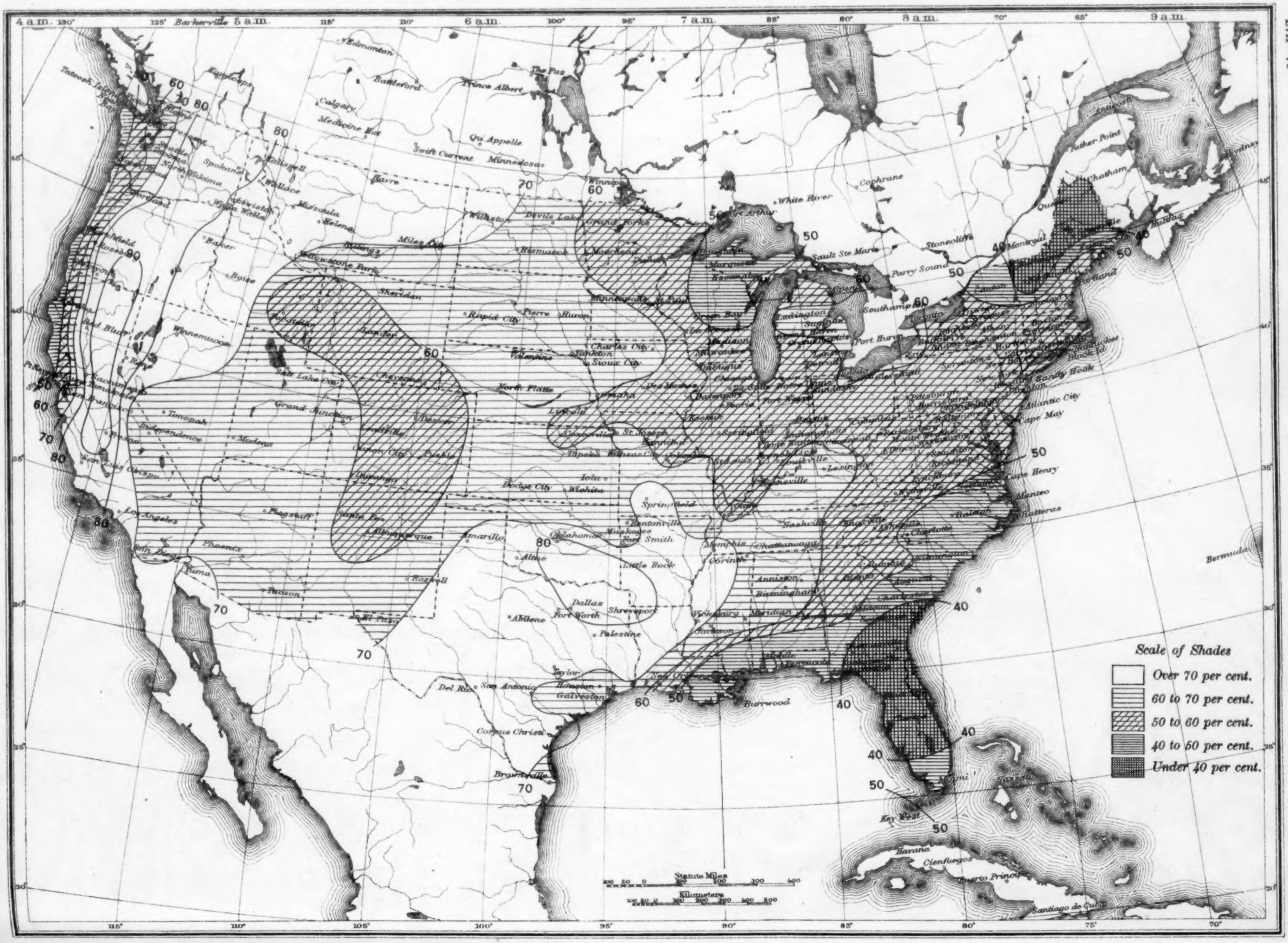


Chart III. Tracks of Centers of Cyclones, August, 1929. (Inset) **Change in Mean Pressure from Preceding Month**

(Plotted by Arthur J. Haidle)

Chart III. Tracks of Centers of Cyclones, August, 1929. (Inset) Change in Mean Pressure from Preceding Month
(Plotted by Arthur J. Hadle)
August, 1929. M. W. R.
I
II
III
IIIa
IV
V
VI
VII
VIII
+.05
-.05

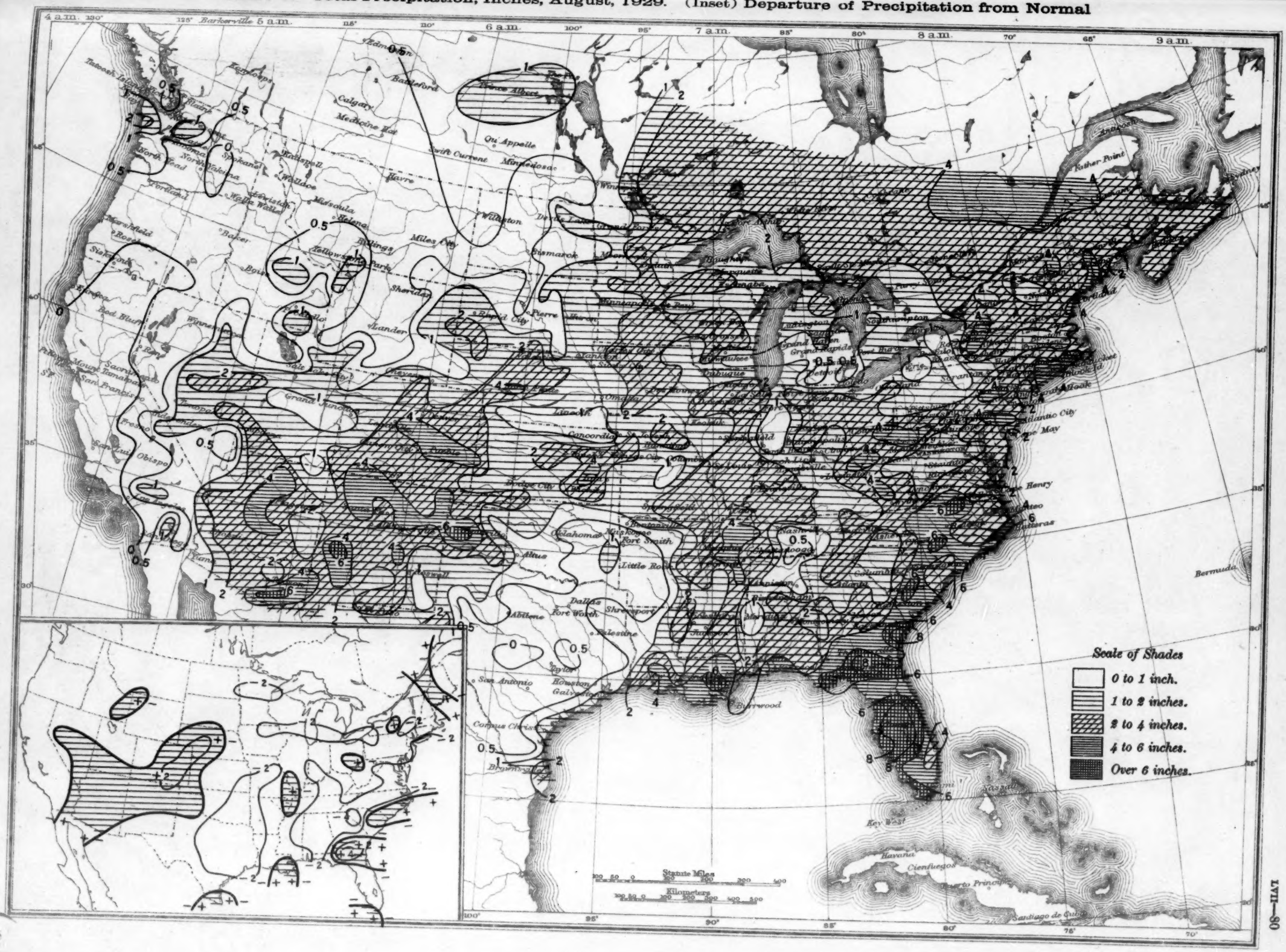
Chart IV. Percentage of Clear Sky between Sunrise and Sunset, August, 1929



August, 1929. M. W. R.

Chart V. Total Precipitation, Inches, August, 1929. (Inset) Departure of Precipitation from Normal

Chart V. **Total Precipitation, Inches, August, 1929.** (Inset) **Departure of Precipitation from Normal**



August, 1929. M. W. R.

LVII—30

Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, August, 1929

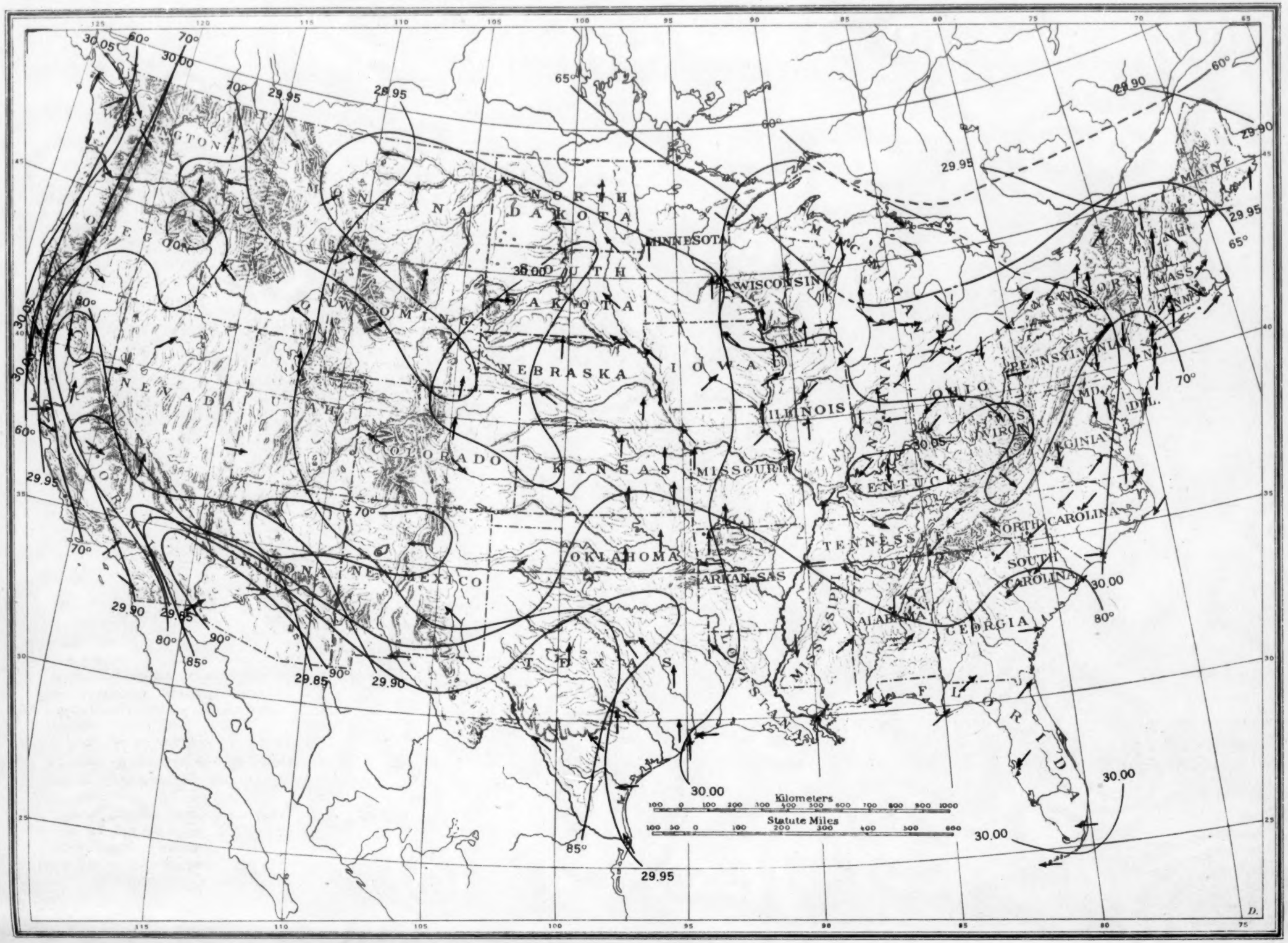


Chart VIII. Weather Map of North Atlantic Ocean, August 1, 1929

(Plotted by F. A. Young)

Chart VIII. Weather Map of North Atlantic Ocean, August 1, 1929

(Plotted by F. A. Young)

Greenwich Mean Noon.

Isobars show corrected barometric readings in inches of mercury.

Arrows fly with the wind.

Number of feathers indicate force, Beaufort scale.

Weather symbols are as follows:

○ clear, ◑ partly cloudy, ● cloudy, • rain, ▲ hail or sleet, ✳ snow, ═ fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.

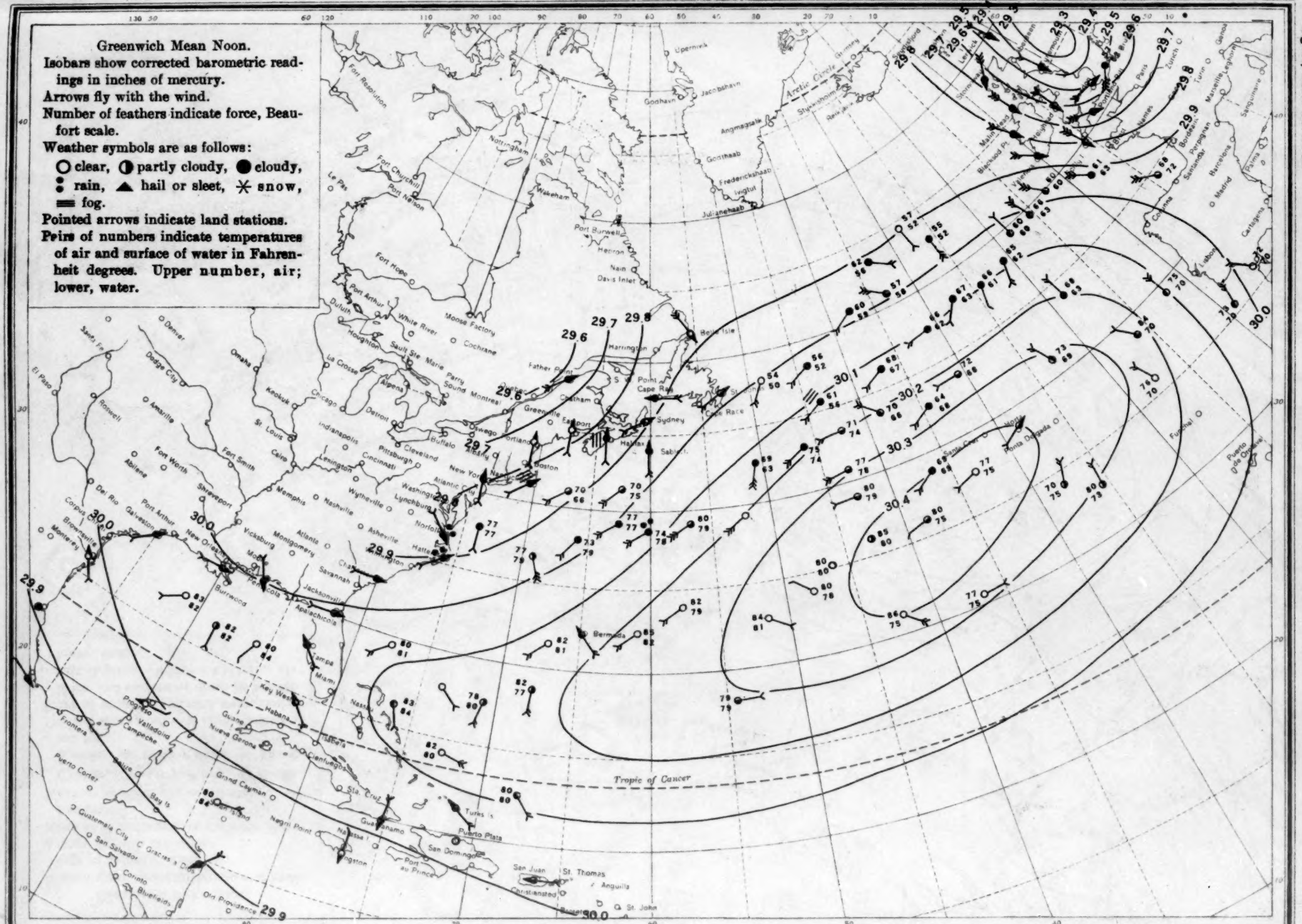


Chart IX. Weather Map of North Atlantic Ocean, August 2, 1929

(Plotted by F. A. Young)

Greenwich Mean Noon.

Isobars show corrected barometric readings in inches of mercury.

Arrows fly with the wind.

Number of feathers indicate force, Beaufort scale.

Weather symbols are as follows:

○ clear, ◑ partly cloudy, ● cloudy, • rain, ▲ hail or sleet, ✳ snow, ▬ fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.

Arctic Circle

Tropic of Cancer

Chart X. Weather Map of North Atlantic Ocean, August 3, 1929

(Plotted by F. A. Young)

Chart X. Weather Map of North Atlantic Ocean, August 3, 1929
(Plotted by F. A. Young)

Greenwich Mean Noon.

Isobars show corrected barometric readings in inches of mercury.

Arrows fly with the wind.

Number of feathers indicate force, Beaufort scale.

Weather symbols are as follows:

○ clear, ◑ partly cloudy, ● cloudy, ⁝ rain, ▲ hail or sleet, ✳ snow, ≡ fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.

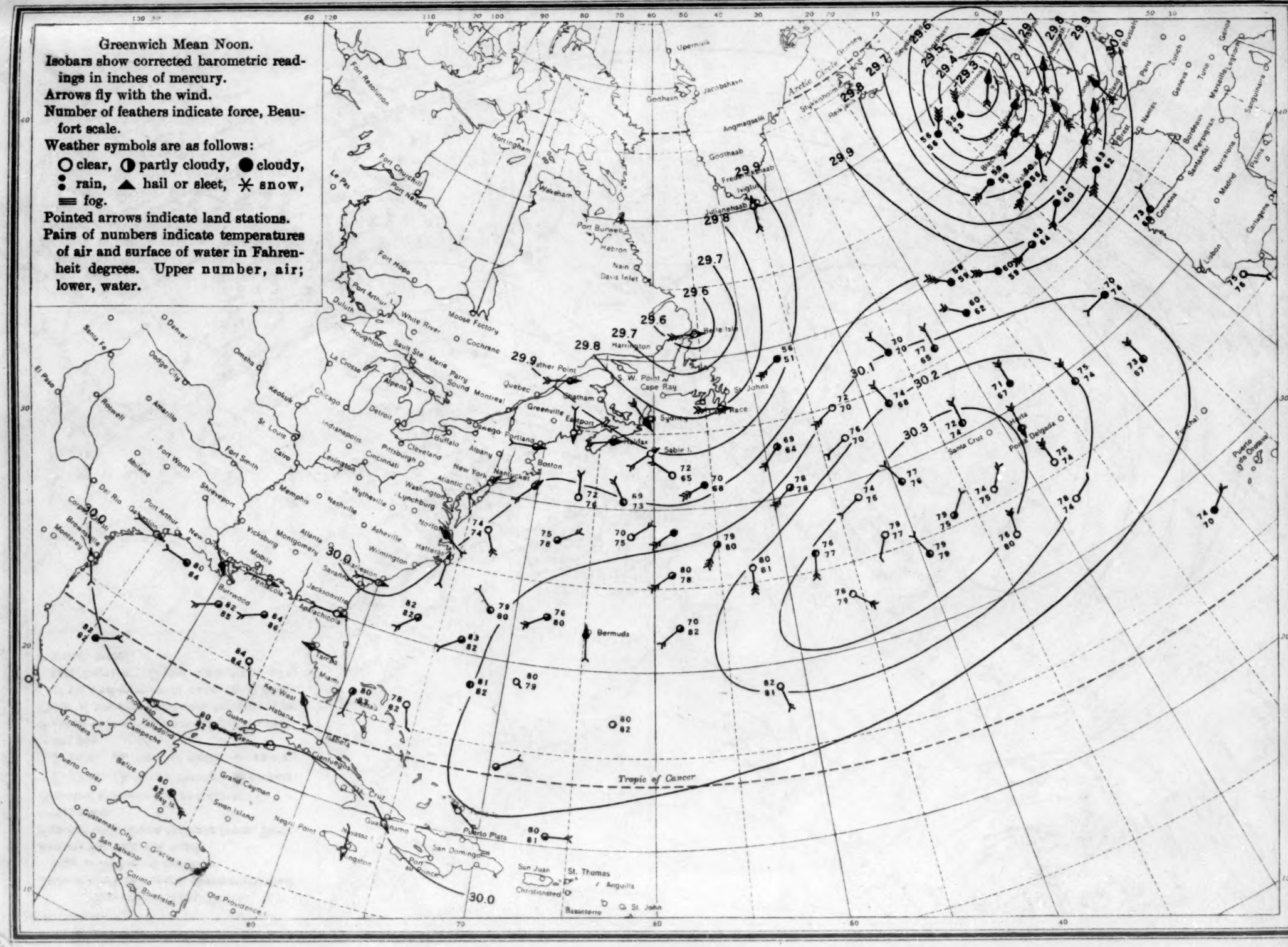


Chart XI. Weather Map of North Atlantic Ocean, August 4, 1929

(Plotted by F. A. Young)

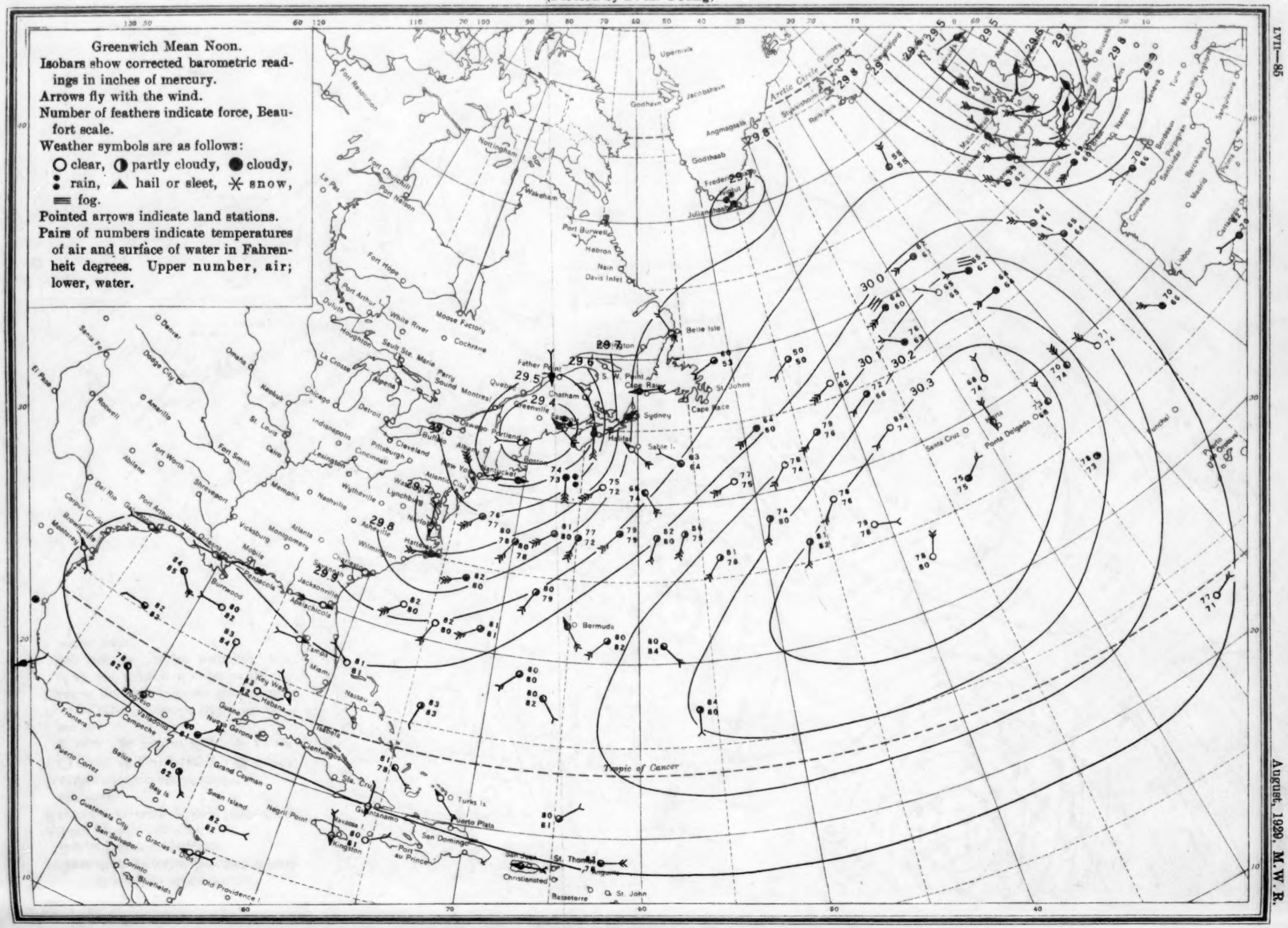


Chart XII. Weather Map of North Atlantic Ocean, August 7, 1929

(Plotted by F. A. Young)

Chart XII. Weather Map of North Atlantic Ocean, August 7, 1929

(Plotted by F. A. Young)

Greenwich Mean Noon.

Isobars show corrected barometric readings in inches of mercury.

Arrows fly with the wind.

Number of feathers indicate force, Beaufort scale.

Weather symbols are as follows:

○ clear, ◑ partly cloudy, ● cloudy, • rain, ▲ hail or sleet, ✳ snow, ≡ fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.

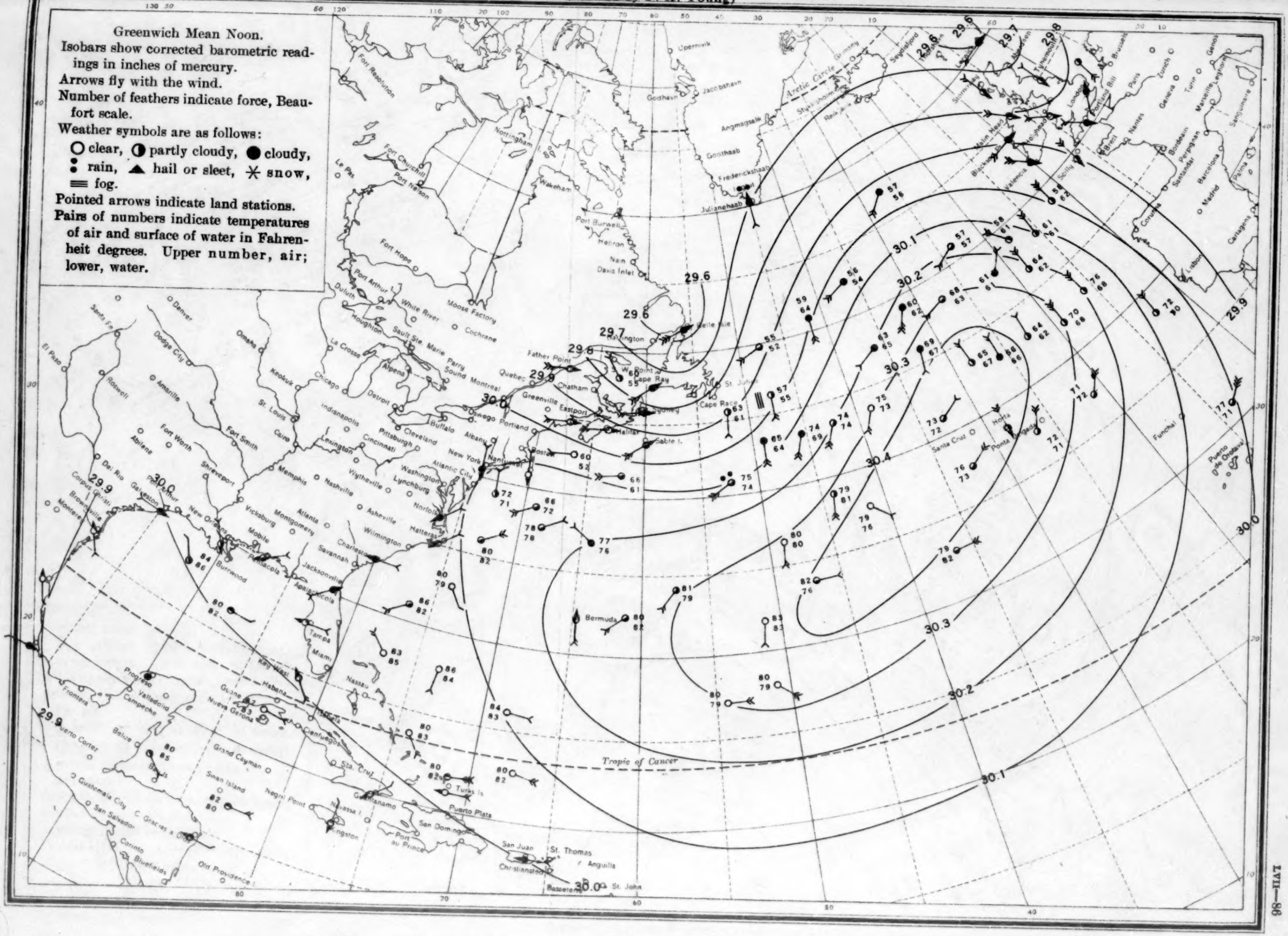


Chart XIII. Weather Map of North Atlantic Ocean, August 8, 1929

(Plotted by F. A. Young)

Greenwich Mean Noon.

Isobars show corrected barometric readings in inches of mercury.

Arrows fly with the wind.

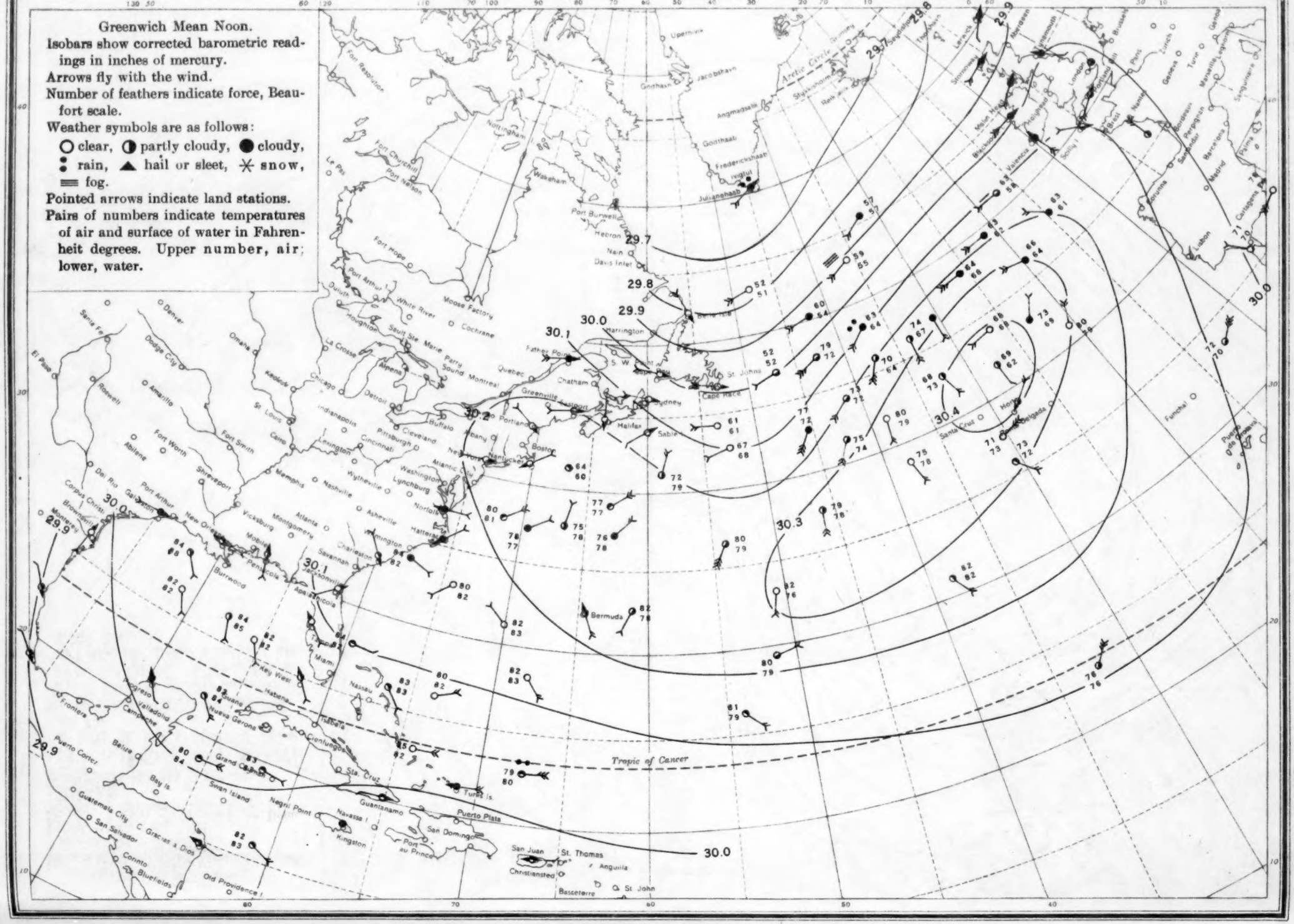
Number of feathers indicate force, Beaufort scale.

Weather symbols are as follows:

○ clear, ◑ partly cloudy, ● cloudy, ⁝ rain, ▲ hail or sleet, ✳ snow, ≡ fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.



August, 1929. M. W. R.

Chart XIV. Weather Map of North Atlantic Ocean, August 9, 1929

(Plotted by F. A. Young)

Chart XIV. Weather Map of North Atlantic Ocean, August 9, 1929

(Plotted by F. A. Young)

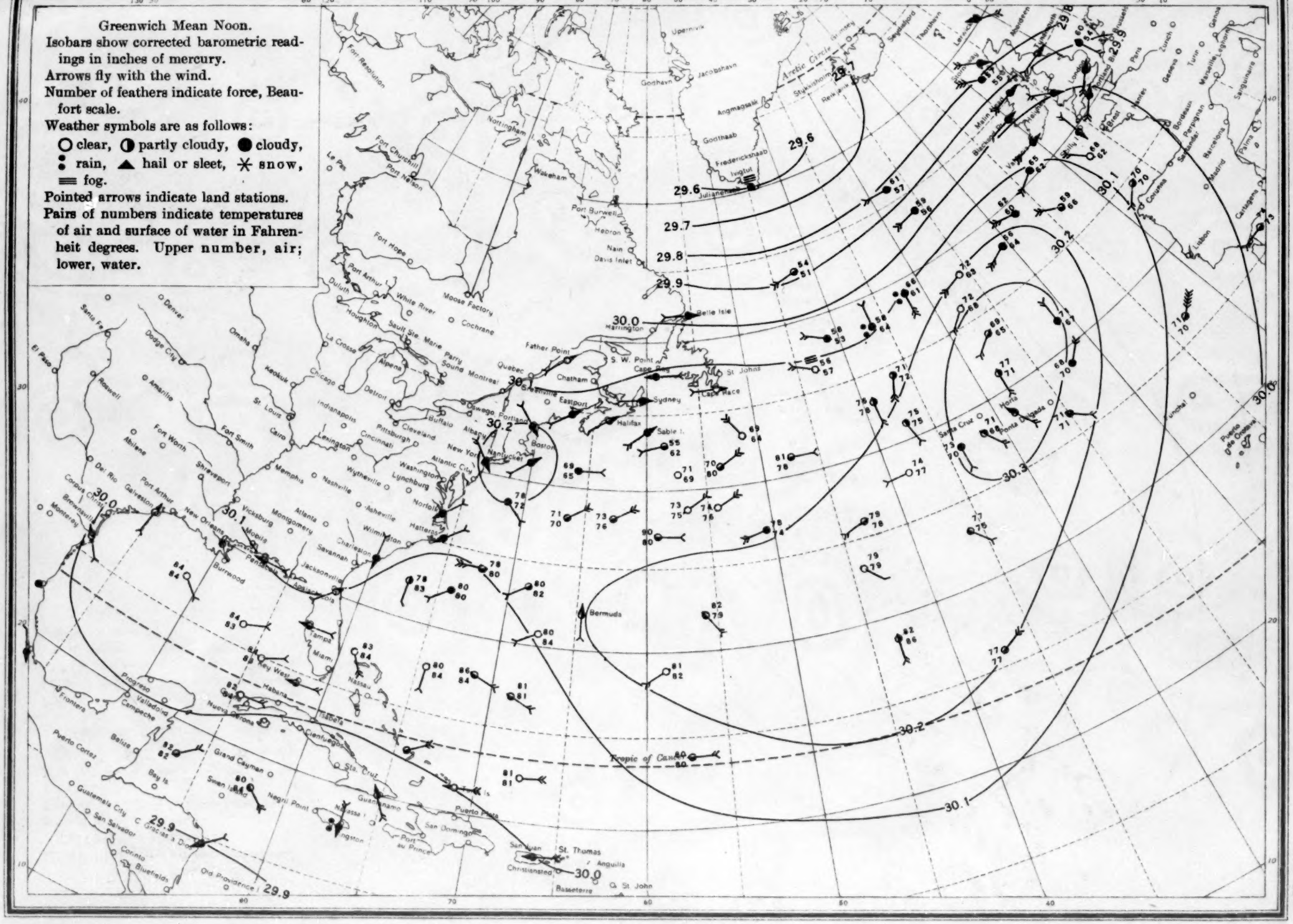
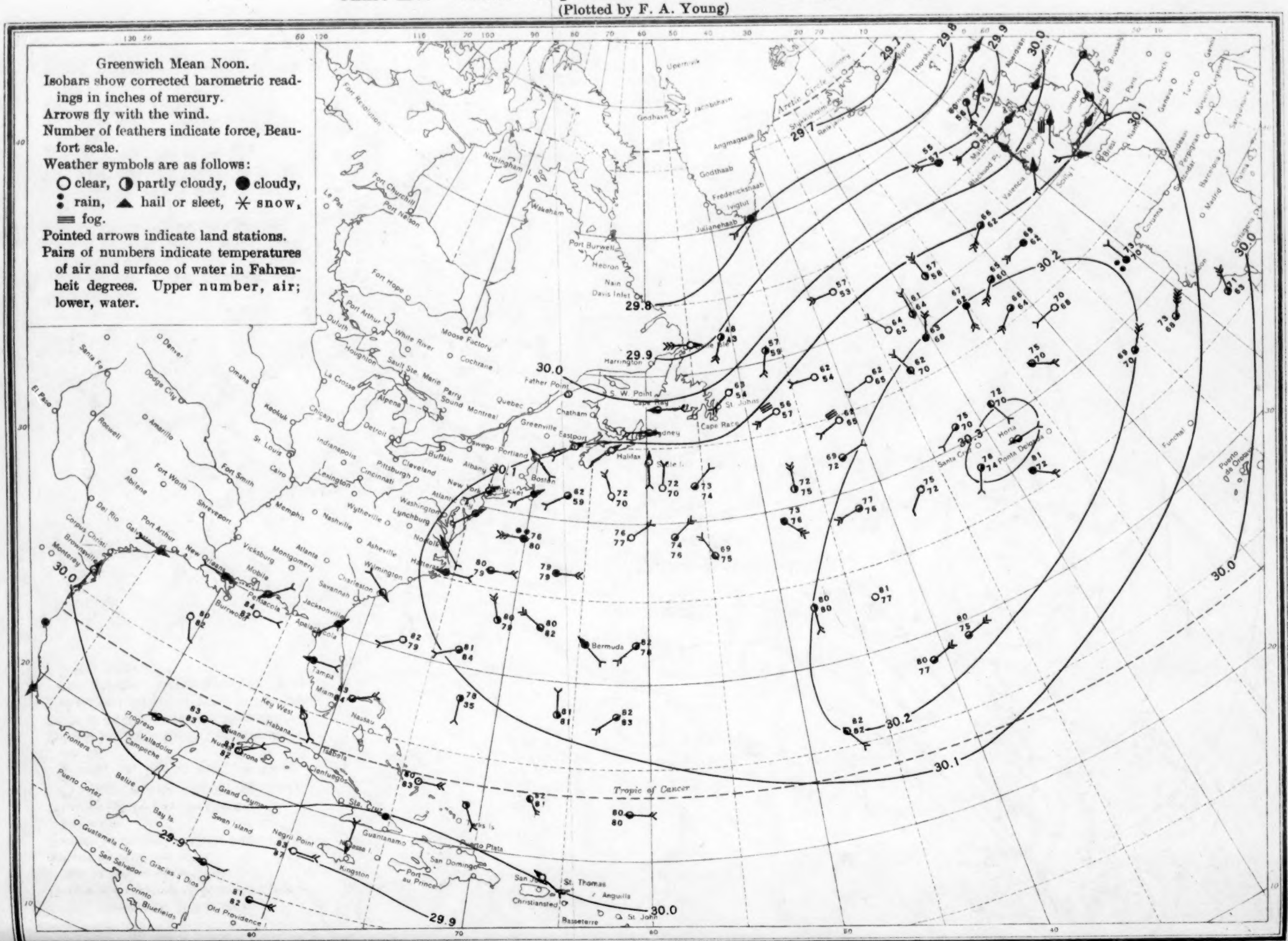

Greenwich Mean Noon.
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy, rain, hail or sleet, snow, fog.
Pointed arrows indicate land stations.
Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.
Arctic Circle
Tropic of Cancer
29.6
29.7
29.8
29.9
30.0
30.1
30.2
30.3
Upernivik
Godhavn
Jacobshavn
Angmagssalik
Stykkisholm
Reykjavik
Grimsey
Seydisfjord
Thorshavn
Lerwick
Aberdeen
Inverness
Stornoway
Oban
Belfast
Dublin
Valentia
Galway
Fort Resolution
Fort Churchill
Port Nelson
Nottingham I.
Wakeham
Le Pas
Port Burwell
Hebron
Nain
Davis Inlet
Goothaab
Frederickshaab
Ivigtut
Julianehaab
Fort Hope
Port Arthur
Duluth
White River
Moose Factory
Cochrane
Houghton
Sault Ste. Marie
Parry Sound
Montreal
Quebec
Belle Isle
Harrington
Father Point
S. W. Point
Cape Ray
St. Johns
Chatham
Charlottetown
Eastport
Sydney
Halifax
Sable I.
Portland
Boston
Nantucket
Albany
Buffalo
Cleveland
Detroit
Chicago
La Crosse
Alpena
Oswego
Toronto
Pittsburgh
Cincinnati
Indianapolis
Lexington
Wytheville
Washington
Atlantic City
New York
Lynchburg
Norfolk
Asheville
Wilmington
Hatteras
Charleston
Savannah
Jacksonville
Atlanta
Montgomery
Vicksburg
Mobile
New Orleans
Pensacola
Burwood
Tampa
Miami
Key West
Nassau
Habana
Matanzas
Cienfuegos
Sta. Cruz
Guantanamo
Negril Point
Montego Bay
Kingston
Port au Prince
Puerto Plata
San Domingo
San Juan
St. Thomas
Anguilla
Christiansted
Basseterre
St. John
Bermuda
Grand Cayman
Swan Islands
Bay Is.
Belize
Puerto Cortez
Guatemala City
San Salvador
Corinto
Bluefields
C. Gracias a Dios
Old Providence I.
Progreso
Campeche
Frontera
Nueva Orleans
Tuxpan
Veracruz
Tampico
Brownsville
Corpus Christi
Galveston
Port Arthur
Monterey
Del Rio
Abilene
Fort Worth
Shreveport
Memphis
Nashville
Vicksburg
Mobile
Montgomery
Atlanta
Jacksonville

Chart XV. Weather Map of North Atlantic Ocean, August 10, 1929

(Plotted by F. A. Young)